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CYCLES.

THERE are those who maintain that what happens to-day has happened before and will happen again, and that the periodic recurrence of an event may be defined with an accuracy almost approaching to the determinations of the exact sciences. All that is necessary is to ascertain the duration of its cycle. In the branch of natural phenomena we are told of the number of years which may be expected to elapse before one great storm will be followed by another. Experts in their respective branches prognosticate without any reserve the date of the next great financial crisis, or the re-appearance of African lions in London drawing-rooms. To scientific cycle-ists (we adopt this spelling to distinguish them from the bi-, tri-, and electric- varieties) the progress of the Salvation Army in this decade, and the propagation of General Booth's scheme in the present year, are easily explainable by the law of recurring intervals applied to religion and philanthropy. Such a law in politics is generally recognised, though careful exponents of the science who are at all jealous of their prophetic reputation, are generally a little vague in their assertions in this department. Political events, like comets, sometimes become wrecked among satellites, their progress retarded, and their cycles disturbed. In the department of History there are two sub-sections—(A) dealing with cases in which history repeats itself, and (B) with cases in which it is repeated by others. In sub-section (B) is included the science of the cycles governing the rediscovery or revival of practical inventions and their supposed anticipation.

We have been partially converted to the views of the cycle-ists. When conversion once begins, there is no knowing where it will end; but, at present, we only pin our faith to the application of the science in the department of History, sub-section (B). By careful study we have acquired such proficiency that we have no hesitation in commencing our public exposition of the science by predicting the revival of the Bourseul telephone project in from eight to ten years' time. We do not put this suggestion forward on mere guesswork but on scientific principles. We have discovered the circumference of its cycle.

When Mr. Latimer Clark kindly sent us the Bourseul article the other day we did not insert it, but remarked that all the information on the subject was well known. Yet it has gone the rounds of the electrical press with all the interest attaching to new material. Our contemporaries, wiser than ourselves, did not overlook the incidence of the law of recurring intervals, and the result of it is we are weeks behind, instead of being, as we fondly imagined, years ahead.

Regarding the matter from this point of view, we are bound to confess that the period which has now received scientific sanction, is a reasonable one. In intervals of ten years *Punch* might republish its obscure jokes and the *Daily Telegraph* its socia! leaders, except for the uncomfortable people whose mission in life it is to discover such coincidences and write to the editors of rival prints to announce their discovery. In earlier centuries the interval would have been longer, but now the storm is fiercer and the stress is greater; so much new material has to be assimilated, that it is excusable to forget the old. And, when the revival comes, there are many to whom the information is new, so that what with those who never knew, and those who knew and had forgotten that they did know, the interest in the subject is wide and general.

We now see that our apologies are due to Mr. Latimer Clark for not recognising that he was the instrument of the mystic power which controls the cycles, as well as to our readers for withholding information of a novel and interesting character. We make haste to amend. Our readers will please consider it has been recently discovered that back in the fifties "a certain M. Ch. Bourseul" conceived the idea of transmitting speech by means of a vibrating disc set in motion by the voice, and, coincident with its vibrations, making and breaking an electric circuit. A similar disc at the

receiving end was to undergo in the same time the same vibration, and speech be reproduced. Bourseul's idea was of telegraphic derivation, and its similarity in outline to the telephone has led to the suggestion that it need only have been submitted to practical experiment to have given us the telephone in '54 instead of '76. We thought it was known long ago, but our readers will please to again consider it has only recently been discovered, that speech would be impossible by the method suggested. The reason why we give below, in an extract from an exposition of the telephone for the general reader. We select this description, because it helps us out with our cycle theory by having permitted itself to be published in 1882. After remarking that in 1854 Count du Moncel referred to Bourseul's suggestion as a "fantastic idea," and in 1879 the same Count du Moncel published an account of the telephone which carried out the fantastic idea, the author says:—It will be observed, however, that the apparatus which he suggested would not be capable of transmitting speech. A vibrating disc, making and breaking an electric current, would enable a simple sound of a certain number of vibrations to be reproduced, but would not be sufficient for the transmission of speech. M. Bourseul did not overlook the complex nature of the sounds of the human voice, but in his paper referred to, failed to suggest any practical means for their electric transmission. Professor Bell claims to have been the first to utilise the "undulatory current" which made the transmission of speech possible. A disc connected with a battery and vibrating against a wire would enable an electric current of definite strength to be sent through the wire a certain number of times in a given period; but the speaking telephone admits of the sending through the wire a current that is not always of the same strength, but whose intensity varies or "undulates," and so is capable of far greater variety than the mere make and break.

THE ELECTRIC CONSTRUCTION CORPORATION, LIMITED.

THE vulgar refrain, "It's wonderful how they do it, but they do," has been ringing in our heads ever since we read the report and balance-sheet of one of the large electrical companies the other day. But light has broken upon our benighted minds, for the *Oracle* (see another page) has spoken. Oracles are usually ambiguous—not so the daily of that name in its article of the 8th inst. It points out that the very important item of £128,117 in the balance-sheet of the Electric Construction Corporation represents shares in subsidiary companies at par, shares included in the original purchase at nominal value, and debts due by subsidiary companies. It then proceeds to dissect the subsidiary companies, and throws doubt on the par value of their shares. The companies mentioned are the Foreign and Colonial Electrical Power Storage Company and the Electrical Construction and Maintenance Company. As the profit and loss account of the E.C.C. is based on this valuation, it suggests that the directors have not been discreet in reckoning the profit at the figure they have done.

The same idea has occurred to others. As the *Oracle* says, the directors are very able men, and we will add the suggestion that had they been able to convert the mass of paper they hold into sterling, they would doubtless have done so. If the value of a thing is what it will fetch, and these shares have not fetched par, it is reasonable to conclude that they are not worth it. No allusion is made in the article under review to the Electric Traction Syndicate, who paid heavily for promotion, and the right to use E.P.S. cells; and so we suppose we must not class the undertaking as a subsidiary company. Perhaps it is better than a subsidiary company, as it is reported to have disgorged cash, and not paper. So much the better for the Construction Corporation, and worse for the Traction Company. There is one other item to which our contemporary does not call attention—the cash balance. Perhaps they thought it was borrowed for the occasion, or hired, to speak more correctly—a kind of dress-coat in which to appear at the general meeting.

We have known men who never had a cash balance, unless they had raised it on loan, and whose only assets consisted of pawn-tickets. But companies are obliged to have their accounts audited, which is a good thing—especially for the auditors.

Some years ago, at a meeting of the old E.P.S. Company, when the younger brother of this balance-sheet was presented, and a paper profit shown, a shareholder, on asking why the profit would not be divided, was met by the chairman, who, with his usual directness, naïvely replied, "Because we haven't got it." They have it now—somehow, and are going to divide it.

We note that the Construction Corporation has taken up the Ward Omnibus business, and rumour credits it with a third of the City lighting, so it will soon have its hands full, and we sincerely hope its large works at Bushbury, not forgetting Millwall, too, likewise its coffers, for they will have to bear a strain under which paper might give way. We hope they will prosper in the good time coming—the electrical sweet by-and-bye.

Premature Announcements.

NOTHING depreciates the value of an invention, or application thereof, or lessens the confidence of the public, more than premature announcements of what is intended to be done. Yet for months and months has a contemporary stated that "in a few weeks" electric omnibuses will be plying on London streets, whilst a short time ago a representative of our contemporary stated that he saw one of the "new 'buses" carrying passengers. That statement was not only erroneous but the chairman of the Ward Electrical Car Company, at the meeting last week, actually said that the details of the contract for the first line of omnibuses had only just been settled.

Electric Lighting Difficulties.

EVERBODY will sympathise with M. S. Z. de Ferranti in his trouble caused by the fire at the Grosvenor Station, even though they may not believe in his system. The complaints regarding the interruption in the supply of light have been so numerous that some customers have regretted having become clients of the London Electric Supply Corporation. The serious and second interruption last week might have been avoided had the "Festina lente" policy been pursued, instead of hastily repairing partially-destroyed converters, and putting up new transformers in a temporary manner.

Accumulator Traction.

IF the announcement be true that the E.P.S. cells can be maintained at a cost of one penny per car mile for 50 cars for traction purposes, storage battery traction should receive a great impetus in this country. The accumulator cars on the Barking line would probably have been remunerative to the General Electric Power and Traction Company had the depreciation been covered by one penny per car mile, and if the cars had been operated in a district where plenty of passengers is the rule and not the exception.

A Broker's View.

THE gradually increasing interest shown in the application of electricity to tramway traction is exemplified in the December report of Mr. W. W. Duncan, who is a well-known authority on tramway matters. Says Mr. Duncan:—"There is always the very important offchance—I look upon it as a certainty before long—of electricity as a motive power largely reducing the working expenses. It is already doing this in a very marked degree in America, where it is adopted in nearly all the towns and cities which I visited; but the system most in use is that of overhead wires, which is entirely unsuited to our country. I applaud the administration of our tramways for being in no hurry, and carefully avoiding anything experimental, but once they are satisfied, and I think the time is coming near when they will be, there will be a complete revolution in tramway affairs, and I trust my clients and I will be in at the feast of fat things."

Electric Traction Data.

WE shall publish in a future issue a paper recently read at the Chicago Electric Club by Mr. T. P. Bailey. Mr. Bailey furnishes data of operating expenses for one particular road carrying 20 electric cars. These are stated to be a little over six cents or three pence per car mile, and doubtless include repairs and depreciation. The author refers to the fact that there are still some complaints of excessive cost for repairs and maintenance of the electrical apparatus, but he insists that the responsibility for this condition does not altogether rest with the manufacturers. The managers of electric roads are exacting a greater mileage duty than is expected of the ordinary railroad steam engine and under conditions much more unfavourable. If they would see that their tracks are in good order, and the same care and attention given to the electric motor that is given to the steam engine, they will have little to complain of. "How rarely," exclaims the author, "do you find an electric motor operated on a track like that prepared for the steam engine? And how seldom do you find a man in charge of the motor who has the intelligence, training and experience of the steam engineer?" We are fully in accord with Mr. Bailey, and we do not hesitate in predicting that the future success of electric railways will be due as much to skilful manipulation as to good design. Mr. Reckenzaun, in his paper on "Electric Traction Data," has shown that the same driver could, after he had acquired the necessary experience, under precisely similar conditions save 25 per cent. of the energy, and it was suggested at the time that comparative power tests should be made with the purpose of ascertaining the skill of the operator. Accidents to motors, switches and gearing will be reduced in a similar ratio by ordinary care and experience combined with that intelligence which the position of a driver demands, but without which no man should be allowed to assume the responsibility.

A Disclaimer

IT is with much pleasure that we insert the letter of Mr. A. W. Stokes on the subject of his report on Count Mattei's coloured electricities. Our correspondent holds certificates from Professors E. Frankland, J. Percy, F. Guthrie and several others, and his own letter will show how a report, which may have been scientifically accurate, can be garbled in the hands of interested or ignorant parties. Probably Mr. Stokes does not know how long and earnestly we have striven in all directions to put down electropathic quackery, but thanks to the aid it receives from the daily press it still flourishes.

British Insulated Wire Co.'s Cable.

WE have received a report by Mr. Charles H. Yeaman, electrical engineer to the Liverpool Corporation, with reference to tests of samples of this cable. The report is decidedly full, but we miss several very important details. We are told, for instance, the manufacturer's number of the galvanometer and other instruments used in making the test, but nothing is said about the quality of oil used in the galvanometer lamp, nor are we informed by whom the terminal connecting screws were supplied, nor whether the emery paper used for cleaning the wire connections was supplied by Messrs. Oakey—its degree of coarseness is not even given. But, seriously, we have seldom, if ever, read a report of a more absurdly bombastic much-ado-about-nothing character, and though we have no reason to doubt the correctness of the tests, the whole of the letter might have been given in a few lines. Of the value of the tests it is difficult to judge from the insufficiency of information. It is not stated, for example, whether all the cables were lead-covered; if they were, the statement that the insulation of a certain cable kept in the rain for 10 days was good owing to the "impregnation during manufacture with a heavy oil" is absurd, it is simply due to the soundness of the lead-covering, a soundness which is nothing remarkable. The only test made of the moisture resisting properties of the insulated material appears to be that of a piece of electric light cable *two yards* long with the lead stripped off soaked in water for 24 hours, a test which, of itself, is insufficient to be conclusive. We do not say that the cable is not good, but as yet, we have heard of nothing which indicates that it is better than that of other manufacturers.

ELECTRIC LIGHTING AND TRANSMISSION OF POWER IN ITALY.

AN important installation for the transmission of electrical energy for lighting and motive power purposes is now being carried out by the Italian Edison Company, near Intra, in Italy, for Mr. Carlo Sutermeister. This gentleman has a concession of 840 effective H.P. situated near the latter town, which is about six miles distant from Pallanza. The fall of water is 135 feet, and the quantity about 440 gallons per minute. It is obtained from a canal which is fed from the S. Bernardino river, near Cassagno, and runs for some distance in tunnels. The installation, when completed, will comprise four Girard turbines, each of 150 H.P.., and each being coupled direct to a dynamo having an output of 96,000 watts (32 ampères at 3,000 volts), and an exciter of 4,000 watts capacity (40 ampères at 100 volts), and one Jonval turbine of 150 H.P., which also actuates an alternator and exciter of the same capacity. The turbines are fitted with an automatic regulator recently designed by Messrs. Ganz & Co. The plant will be used for supplying light and power to Intra, Pallanza, and neighbouring districts. The considerable distance between the generating and distributing stations rendered it necessary to use the same conductor for transmitting energy for both lighting and power purposes. The Edison Company therefore adopted the alternators, turbines and motors made by Messrs. Ganz & Co., of Buda Pesth, whilst the remaining electrical apparatus—transformers, lamps, meters, &c.,are being supplied by the former company. The conductor, which is of bare copper wire, is being carried overhead on oil insulators, attached to standards, and the loss in transmission from one station to the other is estimated at 10 per cent. The efficiency of the turbines is guaranteed to be 75 per cent., of the alternators 88 per cent., and the transformers from 90 to 95 per cent. The motors will range from 3 to 50 H.P. Those from 3 to 20 H.P. will be energised from separate transformers, whilst the larger motors will receive current from the primary conductor at 3,000 volts, these motors being arranged in series. The current will be measured by Blathy wattmeters, and the installation is to be in full operation in March next.

THE ELECTRIC LIGHT IN PARIS AND THE SMOKE DIFFICULTY.

THE Council of Hygiene and Salubrity of the Seine last week appointed a committee composed of MM. Léon Colin (President of the Army Health Council), A. Ganthier (Professor of Chemistry to the Faculty of Medicine), Léon Faucher (Chief Powder and Saltpetre Engineer), Linder (Inspector-General of Mines), and Michel Lévy (Chief Engineer of Mines), to study the dangers of smoke from a hygienic point of view, and to prepare a scheme of regulation. It may be remembered that in June last the Council expressed the opinion, but in vain, that the electricity stations and motor force works, which produced a deal of smoke, should be placed among establishments which were regarded as dangerous, unhealthy, or inconvenient.

What with the smoke difficulty and the obstruction caused to the traffic by the laying down of the canalisation, the electric light is receiving quite its fair share of attention in Paris. It is also being discussed now from another point of view, one of our contemporaries printing the following article under the heading of "Precautions to Take":—

A beginning has hardly been made to instal the electric light in Paris, and already it begins to show itself as a cause of accidents. This is nothing surprising, and is not of sufficient gravity for one to deduce therefrom the condemnation of this kind of lighting. Side by side with its particular inconveniences it presents great advantages, which are quite special to it. But in the facts which were set forth at the Municipal Council recently in connection with the fire and explosion caused by electricity in a café on the boulevards, an accident which was the twenty-first which had happened at the same place, one conclusion was seen very clearly—an effective surveillance of the electrical posts and installations. At the present moment, small electrical installations made inside a house, when the electro-motor power does not exceed 60 volts for alternating currents and 500 for continuous currents, escape every kind of surveillance. One is not even obliged, before establishing them, to previously officially notify the competent authority or the prefecture of police.

This is an instance for obtaining an alteration in the present state of things; but as time will be necessary, and that maybe the instance will not come to anything, there is certainly something else to do. Why should not the authorities of the City of Paris introduce into the agreements for concessions of electric lighting conditions of a nature to protect public safety? Why should they not require, for instance, the concessionaries to agree to an efficacious inspection of *all* their installations by a competent administrative service? Why not compel them also to establish their works and stations under such conditions that neither smoke, vibrations, nor other inconveniences of which complaint has been made should arise in the future? The electrical concessions are a bargain, an agreement between the authorities of the city and the concessionary; no one, therefore, could object to the former requiring from the latter, in exchange for advantages conceded, certain dispositions which are now recognised as necessary for the public safety and health. This is the more necessary, as the agreement between the city authorities and the Gas Company will grant the latter—if it be definitely settled—the right of working the electric lighting, and the working of the Gas Company will very probably be by means of small installations of the nature of those which at present escape all species of control. It is not therefore useless, in our opinion, on this particular point to call not only public attention, but also that of the Third Committee of the Municipal Council and that of the Council itself, to the subject. The precaution which we indicate would quite naturally find its place in the agreement which the Third Committee of the Municipal Council has under consideration at the present moment.

THE ARTIFICIAL LIGHT OF THE FUTURE.*

By PROF. EDWARD L. NICHOLS.

AS we review the history of the electric light, we find that in two respects there is little cause for congratulation. When we come to consider the quality of the light produced and the efficiency of the apparatus as a light-making machine, we find that the incandescent lamp of to-day produces the same quality of light which the earliest examples of its type were capable of giving. It is true that the efficiency of the incandescent lamp has gradually risen from 5 to 3 watts per candle, but those who have had occasion to trace the discouraging life curves of such lamps know how little real progress the change implies. We start a well manufactured lamp at any temperature we please, provided that we do not pass a certain limit, beyond which the life of the lamp would be too seriously curtailed. The initial efficiency may be made as large as we please, within that limit; but it is only a question of a few days or hours when the lamp will have dropped to the dead level of mediocrity, the 5-watt level which seems to mark the confines of permanency in the case of incandescent carbon.

* Abstract of paper read before the New York Electric Club, November 20th, 1890.

In some experiments made by me, in the first instance a lamp was started at the candle-power indicated by the maker, and was held at constant voltage by means of the current from a storage battery. The initial candle-power was 16, which was obtained at the expenditure of 3·015 watts per candle. Measurements of electromotive force and current were made at intervals of about 10 hours, during the 800 hours that the lamp lasted. The candle-power was redetermined at intervals of about 100 hours. The voltage never rose more than 0·65 volt above its initial value, and then only for a short time. The average electromotive force of the entire run was 0·40 volt below the initial value. The characteristic features were rapid, followed by slower falling off in candle-power, the decrement amounting finally to more than 50 per cent., and rapid, followed by slower, falling of efficiency, to a final value of 5·75 watts per candle. These changes were accompanied by continuous and marked increase in the resistance of the filament.

If it be asked whether this individual case represents a state of affairs common to all incandescent lamps, I can only say that in my experience, which is certainly much less extensive than that of some others, I have known of no class of lamps the performance of which did not agree approximately with the latter results. Mr. W. H. Pierce,† who described extended tests of the initial and average efficiency of incandescent lamps in a paper read before the Institution of Electrical Engineers some time ago, recorded no exceptions to this rule of decreasing candle-power and efficiency with time.

This falling off in candle-power exhibited by lamps maintained at constant voltage can be met by a procedure not easily applicable, perhaps, in commercial work, but readily carried out where the object in view is simply to study the behaviour of the lamp under unusual conditions. The method consists in raising the electromotive force at short intervals of time by amounts sufficient to restore the candle-power to its normal value.

The results of such an experiment performed upon a lamp showed that under this treatment the life of the same was not quite 100 hours. The total rise in electromotive force during the test amounted to about 9 volts; the efficiency decreased from 3·118 watts per candle to 3·468 watts per candle. The resistance of the filament rose from 221·6 to 234·8 ohms. During the first 50 hours the changes were slight, then occurred a sudden increase of resistance, accompanied by marked rise in electromotive force and in amount of energy consumed.

The life history of the incandescent lamp at still higher temperatures does not differ essentially from that which we have just been considering, but the changes in question go on much more rapidly.

In another experiment, a lamp was started at 57 candles. It was maintained at constant voltage for 11 hours and 30 minutes, when it went out. During its brief life the candle-power fell to 24·6c., and the watts per candle increased from 1·58 to 3·09. The loss of candle-power during the experiment was 55 per cent., an amount which corresponds very closely with the loss suffered by the first lamp tested during the 800 hours that it lasted. In the case of another lamp, the initial candle-power (64 candles) was maintained throughout. Its life under these circumstances was 140 minutes, during which short period it had been found necessary to raise the electromotive force from 114·08 volts to 129·53 volts. The efficiency of the lamp fell, meantime, from an initial value of 1·33 watts to 1·677 watts at the end of the first hour; then more and more rapidly to 1·945 watts at the end of the test.

The conclusion to be reached from these data, and from the great mass of experimental results which has accumulated since the incandescent lamp has become an object of investigation, is only too evident. The efficiency of an illuminant in which carbon is the glowing material is a function of the temperature. It appears that the incandescent lamp is fairly stable only at temperatures for which its efficiency does not exceed about five watts per candle. We have just seen what occurs when one attempts to maintain lamps at degrees of incandescence corresponding to a much higher temperature. It is, perhaps, not possible to point out with perfect definiteness all the causes that are at work to reduce the candle-power. The black coating which gradually forms on the interior of the lamp-bulb intercepts more and more of the light from the filament as the age of the lamp increases.

With regard to the absorbing power of this film, it was found that this was very nearly uniform throughout the spectrum, so that the blackening of the lamp had no appreciable effect upon the light which it emitted; also that the absorption at the end of 200 hours was considerably more than half as great as that at the end of 800 hours, and that the total loss of candle-power due to blackening was about 22 per cent.

These measurements enable us to account for rather more than one-third of the loss of candle-power suffered by the lamp. We are not, with our present knowledge, in a position to speak so definitely concerning the other two-thirds, but the increase in the resistance in the carbon indicates another source of diminution. That gradual failure of the vacuum which the use of the spark coil would unquestionably have enabled the observers to detect, may well be answerable for the rest. Now, the temperature of an incandescent lamp filament at 5 watts per candle is very nearly the same as that of the carbon in the light-giving flames produced by the combustion of oils and gas, and it appears that the attempt to pass this temperature introduces difficulties of such a nature as to lead to the serious question whether we have not reached a definite limit, beyond which incandescent carbon ceases to be permanent.

At that limit the efficiency of the lamp is very small indeed, 95 per cent. or more of the radiant energy emitted being of wave lengths too long to afford light.

As to the arc light, no more encouraging report can be made. On the contrary, it is perfectly well established that the quality of the light, instead of increasing, has fallen off, in the course of the development of the lamp from the clock-work regulators of Dubosc and Foucault, with their slender carbons, to the commercial lamps of to-day.

In the vast accumulation of experience which the past years have witnessed, nothing has come to general knowledge which looks to the raising of the barrier which blocks our progress. It seems only too probable that the limiting temperature at which carbon can be used for the production of light has been reached, and with it the maximum efficiency of artificial illumination.

What is to be the light of the future? From the standpoint of the engineer, I will frankly say that I cannot answer that question; but abandoning the directly practical point of view, there is something to be said. I need offer no apology here for presenting facts, the application of which is at best remote, and the present importance of which is therefore rather scientific than utilitarian; nor need I remind you that all the so-called "forces of nature" which have been yoked and impressed into the service of man, were the object of scientific curiosity, and the subject of scientific investigation long before the idea of a practical application was entertained.

The number of elements and of compounds capable of sustaining a high temperature without dissociation or change of state is very large. Carbon is the only one of these, the capabilities of which, as a source of light, can be said to have been fully tested; and yet all the others, when heated to a proper point, emit light-giving radiation. Take for example the metallic oxides. We heat the oxide of calcium in our magic lanterns, and it gives us a light of great intensity, and but little inferior to the arc light in whiteness. The exceeding clumsiness of our method of rendering it incandescent, however, has prevented its adoption, excepting for car-

† W. H. Pierce: *Transactions* of the American Institute of Electrical Engineers, vol. vi., p. 293.

tain special purposes. We burn magnesium in fireworks and for photographic flash lights, and occasionally we indulge in the luxury of igniting a bit of the ribbon, and admiring, for an instant, the intense brilliancy of its flame. Now, magnesium is one of the most abundant elements on the face of our planet. It is a rather costly metal at present, being quoted at 50 cents an ounce in this country, and at about half that price on the continent of Europe. Even under the limited demand for it which exists at present, it has fallen to about one-tenth of its price of a few years ago, and I feel sure that it lies within the power of the electrician to greatly further reduce the cost of production. Among artificial illuminants, magnesium has in one respect no equal. W. H. Pickering, who studied its spectrum in 1880, found it to approach sunlight in quality even more closely than the electric arc light does.

Weight for weight, magnesium affords more than 30 times the light obtained from gas, with the development of much less heat. The quality of the light is such that merely from the standpoint of illuminating power, to say nothing of the additional æsthetic value of a light which approaches sunlight in whiteness, each unit of it must be regarded as the equivalent of rather more than 1·25 units of light.

The study of the radiation of the metallic oxides above the red heat reveals the existence of properties which lead us to regard them as being luminescent "by heat." It is from such bodies that radiation of high efficiency is to be looked for. We have in magnesium oxide a member of this particular class, and when it is heated in the process of formation if gives us a light the efficiency of which is unapproached by that of other artificial illuminants.

The problem is easily stated. (1) We need a body which is rendered vividly luminescent by heat. The metallic oxides would seem to offer us many such. (2) The material is to be brought to the temperature at which its luminescence is most marked. Does it not seem probable that the best method, as in the case of carbon, will not be that of direct combustion, but of heating through the agency of the electric current? (3) The material must be restored from time to time. Whether rejuvenation is to be secured through electrical, chemical, actinic or mechanical means remains to be determined.

Luminescence "by heat" offers, however, only a partial solution of the problem of the highest efficiency. However great the efficiency of the luminescent itself, it is accompanied by incandescence of the ordinary kind. The ultimate solution is to be sought for along other lines. Incandescence is too expensive a means of exciting luminescence. There are many other ways in which it may be generated; friction, chemical action, the impact of light waves, electrical excitation, certain vital processes, are known to result in the production of light. The physics of these phenomena is, for the most part, undeveloped. I know of but two attempts to determine the efficiency of this "light without heat," as it has sometimes been called. The intensity is, as a rule, very small, and the heat has doubtless been regarded as quite below the range of even our most sensitive apparatus. One of these two cases is of especial interest to the electrician. It is that of the spark discharge in vacuo. Prof. S. P. Langley and Mr. F. W. Very, in a recent remarkable paper, entitled, "The Cheapest Form of Light," speak of the heat generated in the Geissler tube as so minute as to seem to defy direct investigation. It has, however, been successfully measured by Dr. Staub, of the University of Zurich, by means of one of the most delicate instruments for the measurement of heat—the Bunsen ice calorimeter.*

In Staubb's experiments the vacuum tube was smoked with lampblack and inserted in the ice calorimeter. The ice melted in a given time afforded a measure of the total heat generated by the electric discharge through the tube. A repetition of the determination with the unsmoked tube, under which conditions the light-giving rays could escape, gave the energy of the non-luminous radiation. The efficiency was found to be 3·268 per cent. The extremely small candle-power of light derived from the electric discharge in vacuo, may seem to preclude all questions of its utilisation in practical illumination. The result is one, however, which should not be lost sight of. It suggests a field of investigation which may prove unexpectedly fruitful.

The Geissler tube effect was not the source to which Langley and Very applied the term "the cheapest form of light." The subject of their research was the light of a Cuban firefly. Their work cannot fail to excite the highest admiration of everyone who is able to appreciate the difficulties of such an investigation. The exploration of the heat spectrum of so insignificant a source of light is a task which very few physicists would, I think, have considered practicable, but it has been carried through by these investigators with complete success.

When we study the curve of distribution of energy in the spectrum of the fire-fly thus obtained, and compare it with the corresponding curves for gas light, the arc light and sun light, we find the expression, "the cheapest form of light," which is applied to the light of the fire-fly by Langley and Very, to be fully justified. All the energy of its spectrum is massed within the narrow limits of the visible spectrum, and what is more, by far the greatest part of it is in the form of rays which are especially important for the purposes of radiation, the particular rays which give us yellow and green light. The non-luminous radiation which accompanies the light of the fire-fly seems to be so insignificant that it was with difficulty that it could be estimated, even with the almost inconceivably delicate apparatus used by Langley and Very. They give the efficiency as about 400 times as great as that of a gas flame. It cannot fall appreciably below 100 per cent.

I have endeavoured to show that the efficiency of our present methods is too low to meet the demands of the future for economical illumination, and that whether we ever succeed in approaching the perfect economy of nature's light-making processes, as exemplified in the fire-fly, or not, there are many sources of light which promise high efficiency.

* G. Staub: Inaugural Dissertation, Zurich, 1890 (See the *Beiblaetter zu den Annalen der Physik*, 14, page 538.)

THE ELECTRIC LIGHT AND THE PARIS MUNICIPAL COUNCIL.

[FROM A CORRESPONDENT.]

IN the session of November 24th, to which we referred in our last number, a discussion took place concerning the fire which recently took place at the Grand Café. It was inquired whether the Popp Company was, or was not responsible, and whether it had, in opposition to the regulations, established electric centres in the sunk storey of the Grand Café?

The general secretary of the Prefecture of Police replied, that according to the inquiries made and the declarations received from the proprietors and the manager of the Grand Café, that the Popp Company had installed in an underground hall of the Grand Café, near the gas meter, three batteries of accumulators destined to light up the Grand Café, and partly also to supply a certain number of customers of the Popp Company. The proprietor of the Grand Café had given a written authorisation to the Popp Company to establish a small electric station in their sunk storey, in return for a reduction in the charge for lighting up the establishment; it is alleged that this station supplied about 1,400 lamps outside the café. A continuous current Gramme machine, of 350 volts, sent the current to charge the accumulators. The attention of the council was called to this figure of 350 volts, as of great importance. The engineer of the Popp Company and the manager of the café have declared that safety wires existed in the cables of distribution. As regards the supply cables, the declarations are contradictory. The manager of the café asserts that it is at least the twentieth time that fire occasioned by elec-

tricity has broken out in the café. Two conclusions may be drawn: at present, in most cases, the accidents are produced by the melting of the gutta-percha and the ignition of the wire. A similar accident took place two days later in the Rue de Montmartre and in the place de la Madeleine, the same company having the concession. However, such accidents occur with all the companies. The section of the safety wires is not made proportional to the tensions which it supports and the currents by which it is traversed. It does not fulfil its function. As soon as the current increases in intensity the wire becomes heated, the gutta-percha melts, the wire burns, and a fire breaks out.

The secretary also mentioned as a cause of danger, that small installations in the interior of one and the same property are exempt from the formality of giving notice if the E.M.F. of the generator does not exceed 60 volts for alternating currents, and 500 volts for continuous currents. Such installations like that at the Grand Café can lawfully work in secret. If the company burns down the establishment, no one is authorised to interfere. A modification of the law was therefore urgently demanded, and the universal introduction of safety wires was insisted on.

Another complaint was brought forward on behalf of inhabitants of the Rue Montmartre, who are annoyed by the smoke from an electric station fixed in a neighbouring brewery. Shopkeepers complain that the "blacks" issuing from the enormous chimney damaged their goods. The remedies suggested are the prohibition of coal in boiler furnaces, and the use of coke or of smoke-consuming arrangements.

Many difficulties, however, were pointed out; coke is expensive, and at the electric stations coal of low quality is used from motives of economy. Smoke consumers are not perfectly satisfactory.

The secretary of the Prefecture of Police reminded the council that the visible smoke is not the entire question, as there are injurious gases, such as sulphurous acid, given off in quantity which cannot be got rid of by "smoke consumption" or by the use of coke.

It appears that the electric stations within the city are more especially accused of producing smoke. It was at last resolved, on the motion of M. F. Duval, that there should be distributed to the members of the council, copies of the agreements made with the electric companies and of the agreement giving the Popp Company the right to establish underground channels in Paris.—*L'Electricien.*

SOME FACTS CONCERNING GUTTA-PERCHA.

(*Continued from page* 673.)

The study of the gutta-percha trees, from a botanical point of view, the investigation of the conditions surrounding them from a scientific as well as commercial standpoint, may, M. Sérullas says, be divided into two periods. The first embraces private exploration conducted by such well-known names as Lobb, Oxley, Maingay, Teysmann, Binnendijk, Beccari, Van Leer, and Motley. The second, which may be considered to date from 1881, comprises investigations carried out by various Governments in the interests, primarily, of submarine telegraphy. These include researches effected by Seligman-Lui, on behalf of the French Government, in 1881; Wray, for the English Government, in 1883; Burck, for the Dutch Government, in 1883; and Sérullas, for the French Government, from 1884 to 1889.

During this period Morellet, a Frenchman, spent a considerable time in Malaysia studying the subject, but on a personal and commercial account; and in 1885–1886 Father Scortichini investigated the various species found in the Malay Peninsula. The notes attached to his herbarium, now at Calcutta, were intended to have been incorporated with a history of the flora of the English Straits Settlements.

Commencing with the earlier history of the gutta-percha industry, that is to say, the first period above referred to, there appears to have been a considerable trade previous to 1842 in the hands of Chinese merchants at Singapore; and although in that year Montgomerie made the existence of the gum known to the civilised world, and specimens were brought to Europe in 1843 by Joré de Almeida, yet it was not until 1847 that Thomas Lobb discovered the tree itself, the *Isonandra*, in the interior of the island of Singapore. Ten years after this, the species was considered to have become utterly extirpated in that island, but M. Sérullas discovered a few specimens still surviving in the year 1887.

Between 1847 and 1857, Montgomerie made known that the *isonandra gutta* was to be found plentifully distributed throughout the forests of Saráwak (Borneo), and in the jungle of the Malay Peninsula. He stated that there existed in Malaysia three kinds of gutta, apparently similar as to the tree, but very different in the qualities of the gums, which were distinguished by the natives under the names of *guirek*, *taban*, and *pertcha*.

Oxley went further; he allotted to Borneo alone, seven species of gutta-percha trees. The three best supplied *gutta-taban*, and the best of three was recognised by the yellow colour of the wood.

Confusion now commenced in nomenclature. The native terms were recklessly employed, with the result that the same gum came to European markets under various designations, while absolutely different perchas were labelled with the same name.

To make confusion worse confounded, explorers in search of the *Isonandra* in Malaysian forests, returned with specimens to which purely local names had been given by the natives, the same plant bearing a different title according to the dialect of the locality; and this is not all; it is a fact that during 30 years, these explorers brought back with them not one single specimen of any value. Leaves were indiscriminately collected without regard to the age of the tree, and seldom accompanied by samples of gum obtained at the same time as the leaf.

Later on, as the forests became denuded of the better varieties, the natives made use of species such as *payena*, *bassia*, *sideroxylon*, *chrysophyllum*, and *mimusops*. Used at first secretly for adulteration, these varieties of gum were shortly openly employed in mixtures, to which, again, native names have been given, regardless as to their just application. For instance, the Malaysian name of the *payena Leerii* is *gueutta seundek*; but the guttas-seundek, as known to commerce, are nothing but complex mixtures.

As the above-mentioned varieties became scarce, the natives entered upon the collection of varieties such as the *soughi-soughi* of Singalang, in Sumatra (the *bassia-pallida* of Burck); the *gourhou* of Selangore, in the Peninsula, and in Borneo (the *bassia motleyana*, of Clark; the *fonou* of Tringalang and Pahang, in the Peninsula (the *ganua chrysocarpa* of Pièrre); the *simpor* of Larout and Perak, and the entire south of the Peninsula (the *sidero-carpus Beccarii* of Pièrre, or the *dichopsis maingayi* of Clarke).

Lastly, a fresh series of adulterations have recently been entered upon by the employment of the *djeloutong* (*dyera luxiflora* of Clarke), from Malacca; the *varingin bringin* or *djerindjing* (*urostigma benjaminum* of Miquel), from the Malay archipelago; and the *pohon Saoua* (mimusops Kauki), from the Celebes.

Travellers and botanists have introduced to the notice of the gutta-percha industry, as possible successors to the *isonandra*, a *chrysophyllum* from Brazil, the *mimusops balata* from Guiana, the *bassia Parkii* from Sénégal, and the *dichopsis Krantzii* from Cambodia and Cochin-China.

The French Government, in view of the rapid disappearance of the better gums, and the almost complete extinction of the *Isonandra*, and considering the critical position in which submarine telegraphy was

placed owing to no substitute for gutta-percha being known, deputed, in 1881, M. Seligman-Lui, an engineer in the telegraph service, to make a thorough and comprehensive examination into the actual conditions and circumstance attending the gutta-percha industry.

To the general confusion in nomenclature thus established, M. Seligman-Lui's report to the French Government, which we reviewed in our issue of April 12th, 1884, bore ample testimony, and, curiously enough, M. Seligman-Lui, as we then pointed out, had himself fallen into several errors in the classification of various species, due, no doubt, to the same causes which had led other investigators astray.

With the mission of M. Seligman-Lui the second period may be considered to have commenced. But, continues M. Sérullas, this expedition could not, in the circumstances, succeed in obtaining any definite or conclusive result. How, he asks, could an investigation extending over a few weeks only decide questions which so many explorers, during more than 30 years, had been unable to elucidate.

The voyage, therefore, resolved itself into a search conducted in the forests of Assahan, Sumatra, for some kind of tree which would supply a gum suitable for telegraphic purposes, and any subsequent expedition, instead of undertaking the quest of an *Isonandra* of a particular species, would merely have to apply itself to an examination of a given gum under a local name, and in a forest indicated.

One of the principal objects of M. Seligman-Lui's mission was to discover a tree giving the desired gum, which might be successfully cultivated in French territory. In the forest of Singalongan, on the river Ayer-Siloh, at the extreme limits of the Assahan district, M. Seligman-Lui noticed six kinds of trees called *mayang*, which were easily distinguished from one another. Among these one variety was found, the *mayang taban derrian*, which supplied a gum of the best quality, and which might, without any hesitation, be cultivated, in Cochin-China. Another variety, called the *gutta-batou*, gave a second-class gum, while the rest, known to the natives as *belouk djerindjing*, *korsik*, and *kalihara*, or *kartas*, produced a sap of no value. Young plants of the required species were collected and sent to the French colony at Saigon; and at Siak and Pakan Barhon plants of the *gutta seundek*, and *gutta taban* were obtained and forwarded to the same place.

The authorities in charge of the botanical gardens at Saigon unfortunately lost all these plants, and the Government of the British Straits Settlements was applied to for assistance in the matter. So urgent were the demands, that the Straits Government, convinced of the importance of the subject, deputed Mr. Wray to thoroughly investigate the gutta-percha industry in the State of Perak.

Mr. Wray was especially well qualified to undertake such a mission. Botanist and chemist, he spoke the Malay language perfectly, and in comparing the results of his expedition with those attending M. Seligman's voyage, it is only fair to the latter to mention that in addition to the advantages above indicated, Mr. Wray possessed superior facilities in the matter of time, transport, and finance, as well as exercising absolute control and authority over the natives.

Specimens of nearly every variety of gum-producing tree growing in Perak were collected by Mr. Wray. These specimens consisted of branches, flowers, fruit, wood, bark, and gum, and sufficient samples were obtained to supply the museums of Kew, Calcutta, and Taiping (of which Mr. Wray was director) with complete collections; a further set of specimens was given to Madame Errington Delacroix, who subsequently presented the collection to the Paris Museum of Natural History.

Although Mr. Wray's report was published in December, 1883, little or nothing is known of this, in every sense remarkable, expedition, either in France or Java. M. Brau de Saint-Pol Lias is credited with the discovery of the *gueutta taban mérah*, and M. Errington Delacroix is spoken of having brought to light the *gueutta taban soutra*.

Yet both these trees, which supply most excellent gutta, were discovered by Mr. Wray; the first mentioned at Oulou Plouss, the second at Oulou Kénéring.

Besides these two varieties, the following trees, whose gums are exclusively used for the purpose of falsification and adulteration, were found by Mr. Wray:—

Gueutta Seundek (or *Payena Leerii*; from Sapetang and the Buto River. There are two varieties in the province of Larout.

Taban Pouteh; from the forest of Larout, Kouala Kangsan, Hipoh. Also found in Lahat, Djouang, Taps, Oulou Pahang, &c.

Taban Tchaier; from the falls of Larout, Perak, Pahang, and Patani. There are several varieties of this species.

Simpor; from Oulou Kénéring, Oulou Ploss, Siem, &c.

Simpor; another variety from the falls of Larout.

Djeloutong; from Larout.

Gourbou; from Larout.

The action taken by the Government of the English settlements in the Straits, as a result of Mr. Wray's expedition, was to forbid the cutting of any gutta-percha trees throughout British possessions. This interdiction came, however, too late, as, not long after Mr. Wray's mission, many of the forests explored by him had been entirely denuded of gutta-percha trees.

When M. Sérullas visited Malaysia he had the advantage of being accompanied on one of his trips into the forests by Mr. Wray, who appears to have placed his notes and reports at the disposal of the author of the present article.

(*To be continued.*)

MR. GLADSTONE AND THE TELEGRAPH SERVICE.

THE Right Honourable William Ewart Gladstone has, during his eventful and phenomenal career, been compared favourably and unfavourably to classic mortals and immortals of all types and shades, from "the wily and familiar conjuror," and the indefatigable hairsplitter of everything argumentative, to the simple "Grand Old Man," and the modern embodiment of much anciently held sacred by Greece and Rome. Hero worship, indeed, has caused him to be looked upon by many as the Alpha and Omega of nineteenth century progress, and no praise has been deemed too extravagant wherewith to belaud the vigorous and hearty octogenarian statesman. Those who have not indulged in such perfervid pæans, but have gone to the other extreme, and heaped abuse and unstinted obloquy on the name and fame of the "people's William," stand very much in the position of the negative to the positive current—the zinc to the copper, technically speaking—and the one seems to be, in a sense, indispensable to the other.

It is not our intention to indulge in a political disquisition in these matters, but it may be interesting to our readers to know that in the telegraph service generally, Mr. Gladstone is regarded as a sort of political and telegraphic Hannibal, one whose movements and speeches are regarded by telegraphic clerks with peculiar interest, not to say anxiety, for there never has been a statesman, nor indeed any public man, whose utterances have been so assiduously snapped up by journalists, and incontinently hurled, through the medium of the telegraph service and the press, at the heads and hearts of an always inquisitive reading public.

Into the political aspect of the position of the parliamentary Hannibal we need scarcely enter at great length.

The mighty Carthagenian, the terror of Rome, after crossing the bleak and tempest-scourged Alps, and descending into the fertile valleys of the Po in making his final arrangements for the wonderful campaigns which enabled him to maintain himself in aggressive

hostility to Rome for fifteen years, destroyed the whole of his transport and supplies—a bold and daring step—but fortune favoured him, and his victorious troops found supplies and spoil in plenty in the camps of their routed adversaries.

The modern political Hannibal, it is said, has abandoned his line of communication and his allies, and even now looks with contempt upon those who, in the past, helped him to build up the fame which will make his name a landmark in English history.

The allies of the modern political Hannibal, however well meaning his intentions may be, are not to be mentioned in the same breath with those faithful warriors who followed the amiable and generous-hearted son of Hamilcar through his many vicissitudes in Italy. Unlike the Carthagenian's experience, victory has not at the outset declared itself for the Old Parliamentary Hand, and there is apparently very little or no prospect of it in the near future for those who follow his fortunes.

Returning now to the telegraphic Hannibal, it may be said that were the extra labour and skill called into play in the telegraph service on the occasion of a Gladstone "night" unrewarded, in a pecuniary sense, the alarm and consternation with which the news of the advent of Hannibal into Italy was received in Rome would find a strong professional chord in the heart of the apprehensive telegraph clerk. The first and greatest Midlothian campaign—that of 1880—produced great receptions, great orations, and great political results. An army, so to speak, of reporters plunged into the sea of words, sentences and periods were seized as they flowed in exuberant profusion from the unwearying lips of the great and popular favourite of the million. From the journalist to the telegraph clerk is but a family transfer. In Edinboro', a small army of telegraph clerks, or, as they are now termed, telegraphists, was engaged unremittingly in preparing and sweeping over the wires, north, south, east, and west, the sympathetic sentences of the Old Man militant. Thousands upon thousands of words were dealt with expeditiously and methodically each evening, providing close and monotonous work for hundreds upon hundreds of men throughout the whole English telegraph system. Abundant in rhetorical resource, as the Hannibal of old was inexhaustible in military intuitiveness, Mr. Gladstone is equally at home on the divine blessings of peace, the glories of national freedom, Home Rule, Crown Derby, Homer, large potatoes, the use of jam, or the study of Moses, it follows that the telegraph clerk plays no mean part in the presentation of his utterances to the public. After the Midlothian campaign came the introduction of the Home Rule Bill by Mr. Gladstone in 1886. The scene in the Central Telegraph Department was one never to be forgotten. The day was dull and dark, auguring no good for the gigantic task which the veteran Prime Minister had undertaken in the House of Commons. He began at about half-past four o'clock, and spoke for nearly three hours.

From 4 o'clock in the afternoon until 3 the next morning, upwards of 400 men were engaged in dealing with the transmission of press work incidental to the propounding of this short-lived scheme alone. Extraordinary preparations of circuits, extension and making up of wires, insertions of relays, repeaters, testing of batteries, &c., had been engaging the attention of the officials for some days previously. The heads of departments honoured the scene with a visit, and they must have been surprised to find that the noise alone made the work seem like that of a factory. The number of words telegraphed aggregated fully one and a-half millions. The spirit of the moment was fully entered into by the staff, and the scene was animated beyond all description. Men were seen hurrying here and there with work for the hundreds of operators to whom the task of preparing slips for the Wheatstone automatic had been allotted. Others were to be seen deciphering the wretched "copy," which is generally the source of numerous errors, and also of loss of time. Everything is done on these occasions of extraordinary pressure in a methodical and systematic manner, every man falls into his place, and knows what is required of him to help the general exodus of business.

Through all these times of important pressure, the sheet anchor of the service, and the only one by which monster speeches can be satisfactorily dealt with, is Sir Charles Wheatstone's automatic system of telegraphy, improved very much certainly since its introduction by the inventor upwards of 20 years ago, but still in principle very much the same beautiful, reliable, and perfect medium of communication.

It is a common practice in the General Post Office for the Postmaster-General to express his thanks to the staff for their extremely hard and trying labours at Christmastide, Eastertide, and on occasions of great strain on the service. There are, unfortunately, very few instances where similar compliments have been vouchsafed to those performing such trying and harrassing work as telegrapy in times of strain and pressure, and such instances not infrequently occur. Every gale or disturbance of the elements leaves its mark on the material of the service, and the hackneyed remark is often passed round that, notwithstanding the general improvements effected in the maintenance of wires, batteries and circuits, Nature now and again reminds us that telegraphy, like some of the other sciences, in a measure is still "at the mercy of the elements." Many a disappointment is experienced by the telegraph clerk when these great speeches or great demonstrations occur; he has on such occasions to give up his science class, his art class, his music, his literature, his friends, and the pursuit of pleasure, and it may be of knowledge also. "Duty" is as serious a matter to him as it is to the sentry on his lonely guard. However, he bears it cheerfully and steadfastly, feeling a genuine interest in his duties, and expecting no higher reward than to hear that all went well on the occasion of the great speech, banquet, or demonstration.

Mr. Gladstone has had greater attention paid to him in the matter of his speeches than any other public man during the past 25 years, but this does not mean that other statesmen and men of fame and position at home and abroad are by any means neglected. It simply shows that Mr. Gladstone in office or out of it, popular or unpopular, is read, and we may add criticised, by the masses of his fellow countrymen to a greater extent than is the case with his colleagues past or present—Liberal or Conservative. The recent Midlothian speeches also entailed much expensive labour to the telegraph service, for it is notorious that press work, owing to the absurdly low rate at which it is charged, is a source of great loss to the Department, and on this point we may have something to say hereafter.

INDUCTION AND INDUCTION COILS.

By W. MOON.

THE phenomena exhibited by the variation of the number of lines of induction through the core of an ordinary induction coil may be divided into two parts. Firstly, when the discharge is non-oscillatory, and, secondly, when it is oscillatory. It is with the former of these divisions only that I deal with in this paper.

If l, lines of induction, are threaded through the core of a coil of n turns, joined up to a circuit of resistance R, then the quantity q of electricity produced in the circuit will be

$$q = \frac{n\,l}{\mathrm{R}} \qquad (1)$$

Also, if an E.M.F., capable of producing a steady current C, is put in a circuit, then each time the current is started a quantity of electricity

$$q = \mathrm{L}\,\frac{c}{\mathrm{R}} \qquad (2)$$

will be kept back that would have been generated but for the existence of the coefficient L.

Owing to this factor L impeding the starting of the current in the circuit in a similar manner to that in which the inertia of a body opposes the force setting it in motion, it has been aptly called the electro-magnetic inertia of the circuit. But the shorter but less expressive term of inductance is now more generally used.

The quantity q in (1) is quite unaffected by the presence of any other circuits upon the same electro-magnet. For if l_1 of the same lines of induction are threaded through another coil of n_1 turns, then the quantity

$$q_1 = \frac{l_1 n_1}{R_1} \qquad (3)$$

will be induced in this second circuit while q remains unaltered.

Also when the current, c, is started in the primary circuit the quantity

$$q_1 = m \frac{c}{R_1} \qquad (4)$$

will be induced in the secondary circuit, while the value q in (2) will also remain unaltered.

From (1) and (2) we get

$$l = c \frac{L}{n}. \qquad (5)$$

And, thus, the number of lines of induction threaded through a coil can be determined when the inductance and number of turns upon the coil are known.

Also from (3) and (4)

$$l_1 = c \frac{m}{n_1} \qquad (6)$$

And from (5) and (6) we get

$$\frac{l_1}{l} = \frac{m}{L} \frac{n}{n_1}. \qquad (7)$$

A formula by which can be determined the fraction of the whole number of lines of induction generated by the primary circuit that are usefully threaded through the secondary circuit.

If l equidistant lines of induction cross an area a then the tension along those lines of induction, that is, the pull across the area a

$$= \frac{P^2}{8 \pi a} = \frac{c^2}{8 \pi a} \frac{L^2}{n^2}. \qquad (8)$$

The energy absorbed from the primary circuit in generating the lines of magnetic induction through the core of a simple electro-magnet $= \frac{E q}{2}$ where E is the E.M.F. of the battery.

From (1) and (2)

$$\frac{E q}{2} = \frac{c n l}{2} = \frac{L c^2}{2} \qquad (9)$$

To get as great a pull with as little expenditure of energy as possible in creating the lines of magnetic induction, we must make the quotient of (8) and (9) a maximum

$$\frac{l}{4 \pi a c n} = \frac{L}{4 \pi a n^2} \qquad (10)$$

This last expression is useful in the construction of rapidly responding apparatus such as telegraph relays. But in other apparatus it is necessary to get as great a pull with as small a rate of expenditure of heat in the coils as possible; in that case

$$\frac{L^2}{8 \pi a n^2 r}$$

must be made a maximum, where r is the resistance of the coils of the electro-magnet.

The energy expended by a battery of E.M.F., E, during a time, t, sufficiently long to admit the current arriving at its permanent state

$$= E (c t - q) \qquad (11)$$

where q is the quantity of electricity damped back by L on starting the current.

Filling the value of q in (2), in (11) the energy expended by the battery becomes

$$\frac{E^2}{R} \left(t - \frac{L}{R} \right) \qquad (12)$$

But since from (9) the part of this energy absorbed from the primary circuit in creating the magnetic field

$$= \frac{E^2}{R} \frac{L}{2 R}$$

It follows that the difference between the values (12) and (9) gives the amount expended in heat

$$= \frac{E^2}{R} \left(t - \frac{3}{2} \frac{L}{R} \right) \qquad (13)$$

If there is no secondary circuit this heat will be expended by the current in the primary circuit. But if a secondary circuit exists part of this heat will be expended in that circuit also.

If the same lines of induction are discharged through several secondary coils then the energy embodied in the lines of induction will be divided between the several coils in proportion to the number of turns of each, and inversely proportional to their resistances. Thus the energy expended in the coil of n_1 turns and resistance R_1 would be

$$\frac{E^2}{R^2} \frac{L}{2} \left(\frac{\frac{n_1}{R_1}}{\frac{n_1}{R_1} + \frac{n}{R}} \right)$$

Obviously it is immaterial whether the coil of n turns is a secondary or a primary circuit, and since $\frac{E^2}{R^2} \frac{L}{2}$ is the energy embodied in the lines of induction threaded through the two coils, the sum of these last two values, or

$$\frac{E^2}{R^2} \frac{L}{2} \left(\frac{2 \frac{n_1}{R_1} + \frac{n}{R}}{\frac{n_1}{R_1} + \frac{N}{R}} \right)$$

will represent the energy absorbed from the primary circuit on starting the current.

Thus it will be seen that the whole energy taken from the primary circuit on starting the current cannot be twice as great as when there is no secondary circuit, but approaches more closely to that value as $\frac{n_1}{R_1}$ becomes great as compared with $\frac{n}{R}$.

The time of discharge is important in induction phenomena, as it is by the variation of this factor that the laws of conservation of energy are maintained. Let t be a time of sufficient duration to include nearly the whole of the discharge. And e and e_1 the mean E.M.F. in the primary and secondary circuits during this time, then

$$e = \frac{n l}{t} = \frac{L c}{t} \qquad (14)$$

$$e_1 = \frac{n_1 l_1}{t} = \frac{m c}{t} \qquad (15)$$

And the energy given off in the discharge of the secondary circuit

$$= e_1 q_1 = \frac{n_1^2 l_1^2}{t R_1}$$

$$= \frac{m^2 c^2}{t R_1} = \frac{E^2}{R^2} \frac{m^2}{t R_1} \qquad (16)$$

By adding this last quantity to the energy expended in creating the magnetic field and to that expended in heat in the primary circuit, and equating the result to the energy expended by the battery, the value of t can be determined.

For purposes of illustration, the use of differentials may be avoided by taking proportionality only. Thus:

$$\frac{E\,(E-e)}{R}t \propto \frac{(E-e)^2}{R}\,t + \frac{E^2}{R^2}\,\frac{m^2}{l\,R_1} + \frac{E^2}{R^2}\,\frac{L}{2}$$

Filling in the value of $e = \frac{L\,c}{l} = \frac{E}{R}\,\frac{L}{l}$ we get

$$t - \frac{L}{R} \propto \frac{\left(t - \frac{L}{R}\right)^2}{t} + \frac{m^2}{l\,R\,R_1} + \frac{L}{2\,R}$$

$$\therefore t \propto \frac{2}{L}\left(\frac{L^2}{R} + \frac{m^2}{R_1}\right)$$

It can be shown by Helmholtz's well-known exponential equation that this value of t is equal to the time occupied by ·865, or nearly $\frac{9}{10}$ths of the discharge. So that we may say

$$t = \frac{2}{L}\left(\frac{L^2}{R} + \frac{m^2}{R_1}\right) \qquad (17)$$

If there is no secondary circuit or if R_1 is infinite

$$t = 2\,\frac{L}{R}. \qquad (18)$$

Also if the discharge takes place in the secondary circuit when the primary circuit is broken.

$$t = 2\,\frac{m^2}{L\,R_1} \qquad (19)$$

There is an important difference between the discharge of a condenser and that of a simple electro-magnet.

The current produced by the discharge of a condenser for similar phases of the discharge is inversely proportional to the resistance, and the time of discharge varies directly as the resistance.

But in the case of the discharge of the coil the current for similar phases of the discharge is independent of the resistance while the time of discharge varies inversely as the resistance.

So that in the former case the product of the time of discharge and the current, that is, the quantity q is constant, while in the latter case, the product of the resistance and the time of discharge is constant, and the quantity of the discharge varies inversely as the resistance.

Again, in the case of the condenser, the E.M.F. at similar phases of the discharge is constant, while in the case of the coil it is proportional directly to the resistance and inversely proportional to the time of discharge.

But while the initial current and current for similar phases of the discharge are constant when there is but one circuit surrounding the same lines of induction, yet this is not the case when there are several such circuits. This evidently follows, since the quantity of electriciiy of the discharge from each circuit is not influenced by the presence of other circuits, while the time occupied by the discharge is affected as shown in formulas (17), (18), (19).

Thus, the initial current and current for similar phases produced in the secondary circuit on closing the primary would be but

$$\frac{\frac{m^2}{R_1}}{\frac{L^2}{R} + \frac{m^2}{R_1}}$$

of that produced in the secondary when the primary circuit was broken.

In the same manner, the initial value of the imaginary inverse current, or to speak more correctly, that of the opposing E.M.F. in the primary circuit, would be

$$\frac{\frac{L^2}{R}}{\frac{L^2}{R} + \frac{m^2}{R^1}}$$

of what it would be if no secondary circuit existed.

Hence the presence of a secondary circuit has the effect of making the opposing E.M.F. in the primary circuit smaller in amount for similar phases of the discharge. But the discharge occupies a proportionately longer time so as to maintain the quantity q of the discharge constant.

Since the value of the current in the primary circuit, where no secondary circuit exists, starts at 0, and rises to c. Therefore the imaginary inverse current must start at c and fall to 0.

Similarly if the discharge takes place through the secondary circuit when the primary circuit is broken, the values of the initial current will be

$$c\,\frac{n_1\,l_1}{n\,l} = c\,\frac{m}{L}$$

Hence the initial value of the secondary current on closing the primary circuit will be

$$c\,\frac{m}{L}\left(\frac{\frac{m^2}{R_1}}{\frac{m^2}{R_1} + \frac{L^2}{R}}\right)$$

And the initial value of the opposing E.M.F. in the primary circuit on starting the current will be

$$E\left(\frac{\frac{L^2}{R}}{\frac{L^2}{R} + \frac{m^2}{R_1}}\right)$$

This phenomena presented by the ordinary spark coil depends upon this law of the time of charge and discharge of the coil being proportional to the conductivity of the circuit surrounding it.

For when the primary circuit of the coil is closed, owing to the primary resistance being very small, the time of charging the coil is great, and the E.M.F. induced in the secondary coil not sufficiently great to produce a spark. But when the primary circuit is broken there exists an electro-magnet surrounded by a secondary coil of many turns, but of very great resistance owing to the air space between the discharging points; therefore, the lines of induction collapse very rapidly and charge the poles of the secondary coil to a very high potential. And when the static charge upon the poles of the secondary coil reaches a sufficiently high potential, a discharge takes place and the energy embodied in the lines of induction through the core disappears in the spark so produced.

At any instant of time the ratio of the E.M.F. induced in the secondary to that induced in the primary coil will be

$$\frac{n_1\,l_1}{n\,l} = \frac{m}{L}$$

The length of spark produced in the secondary circuit will, however, not depend directly upon the E.M.F. induced in the secondary coil, but upon the static potential at the discharge points, which will be somewhat less than the induced E.M.F. owing to the static capacity of the ends of the coil and the discharge points.

It is a familiar induction coil experiment to join a condenser to the two poles of the secondary coil, and thus, by reducing the static potential of the discharge points to obtain shorter sparks, but of greater volume, in proportion to the capacity of the added condenser.

The function of the condenser attached to the primary coil of all induction coils, is also, of course, to reduce the static potential at the contact points, and thus prevent sparking.

In some shocking coils, the severity of the shock is regulated by thrusting a copper or brass tube over the iron core. The function of this tube is twofold, as besides absorbing a portion of the energy given off by the primary circuit, it also reduces the rate at which the lines of induction through the core collapse, and thus reduces the induced E.M.F. in the secondary circuit.

SMITHFIELD CLUB SHOW.

AT this show, held during the current week, the leading makers displayed some excellent specimens of steam engines, specially designed to combine the requisites of a good prime motor for electric lighting. At the stand of *Messrs. Marshall, Sons & Co.* is exhibited a 10 H.P. nominal compound stationary steam engine, erected underneath a locomotive multitubular boiler. The equipment includes Hartnell's patent automatic expansion gear, automatic sight feed lubricator, and a steam trap for draining the cylinder jackets. The engine and boiler are constructed of ample strength for a working pressure of 140 lbs. to the square inch, and are specially adapted for electric lighting. They also showed *two* engines worthy of special attention, one of which is a new pattern (Class "M") independent *vertical* engine, cylinder 6½ inches by 10 inches, fitted with *Moore's patent* crankshaft governor, and automatic cut-off balanced slide valve, and a patent automatic sight feed lubricator, &c. The engine is specially adapted for electric lighting, there being ample provision for lubrication, and the governor controlling the engine to such a nicety, that there is practically no variation in the speed, however much the load may change. The other is a self-contained engine of the *horizontal* type (Class "M"), with cylinder 10 inches by 14 inches. The equipment of this engine is exactly similar to the vertical named above, with the addition of forcepump. This is also specially adapted for electric lighting or other machinery requiring steady running.

Messrs. Robey & Co. exhibited a compound "Robey" engine and locomotive boiler combined, of the type so largely used for electric light installations, and for driving other machinery where perfectly steady running is required. It is very powerful for the space occupied, works with perfect regularity with very varying loads, and is extremely economical in fuel, consuming under 2 lbs. of best Welsh coal per indicated horse power per hour. The working parts are perfectly balanced, so as to run safely at high speed, and as they have large wearing surfaces of ample size they run cool under heavy loads. It is well lubricated for long runs. At this stand is also shown a high speed vertical engine, specially designed for working electric light machines on board ship, and in flour mills, but it is equally suitable for any other purpose where great power is required in small space. It is designed to work with a high steam pressure, and may be arranged to run at various speeds as may be most suitable for the work it has to do. All the wearing parts have very large surfaces, and it is fitted up with means for self-lubrication, so that it may run continuously, without any risk of heated bearings. While every part of it is thoroughly well lubricated, it is so arranged that no oil is wasted. When used for electric lighting it is mounted on a cast iron bed plate, the other end of which carries the dynamo. The baseplate is provided with lugs and adjusting screws, so that the driving bolt can be tightened without stopping the machinery. The engine is perfectly balanced, so as to run at a high speed, without excessive wear, and the whole forms a strong, durable, and compact motor, which can be thoroughly relied upon to work economically and safely during long runs, without giving trouble. Another class of engine represented is the "long stroke horizontal fixed engine," fitted with patent automatic expansion gear. This engine is designed for high pressure of 80 lbs. to 100 lbs., and is provided with steam-jacketed cylinder, with liner made of specially hard close-grained metal, extra long crank-shaft, with long bearings, solid end connecting rod, and all working parts of ample size and strength to work continuously with pressure of from 80 to 100 lbs. steam. It is fitted with Richardson's patent automatic gear and governor, which gives a range of admission from zero to three-quarters of the stroke, and a very perfect distribution of steam. A "horizontal fixed engine" was also shown, fitted with patent trip expansion gear (Class "E"). When steam engines are of large size, and work with steam of high pressure, the working of the slide valves becomes an appreciable part of the load upon the engine, and to obviate this various kinds of equilibrium valve gear have been introduced, the best known among them being the Corliss, with rotating valves, and the Sulzer, with Cornish double beat valves, a variety of which is known as the Proell gear. All these gears are manufactured by Robey and Company, and can be fitted to their engines when required; but their large experience with the different varieties has enabled them to discern the weak points in each kind, and as a result they have produced a patent trip expansion gear, which is the simplest, most effective, and most easily worked, and gives the most satisfactory results of any hitherto made.

Messrs. Hornsby and Sons showed one of their under type stationary compound engines of 10 H.P., fitted with loco. type boiler, which are in use largely both at home and abroad for electric lighting owing to their economy in consumption of fuel, steadiness of running, and the small amount of space occupied. This engine is fitted with Hornsby's patent automatic expansion gear, and also feed-water heater. A vertical engine for high speed is also worthy of notice. This is of 4 nominal H.P., and is specially designed for electric lighting purposes on board ship and other places. This engine, when driving a suitable dynamo, is capable of running 80 to 100 16-C.P. incandescent lamps, and is of course also suitable for any purpose where a high speed and great power in small space are required.

Amongst the engines shown by *Messrs. Ransomes, Sims and Jefferies*, and by *Messrs. Ruston, Proctor and Co.*, there were also several particularly adapted for driving electrical machinery, of some of which we have published full particulars on other occasions.

Messrs. Wilcox & Co. made a good display, as usual, of machine belting, lubricators, oils, and the large variety of engine-room requisites supplied by the firm.

NOTES ON ECONOMY IN CONDUCTORS IN SYSTEMS OF DISTRIBUTION OF ELECTRICAL ENERGY.*

IN considering what economies it is possible to introduce into a system of conductors laid down for the distribution of electrical energy, one has at the outset to consider the relative merits of the different systems which have been proposed before investigating the best proportions to be given to different parts of the system fixed upon, and the proper current densities to be employed in them.

With regard to this first question, I do not propose to say more than a very few words, or to deal with it in any but the most general way.

It is important to observe, in the first place, that the pressure to be used in houses for lighting by incandescence lamps has been practically limited to a maximum of 100 to 120 volts by the makers of the lamps, and that the pressure in buildings may not in any case exceed the 300 volts fixed by the Board of Trade. This consideration, while greatly hampering the system of simple parallel distribution, does not affect to any great extent the rival systems employing accumulators or secondary generators.

In his Cantor lectures before the Society of Arts in 1885, Prof. George Forbes gave a very interesting account of various systems and their sub-divisions; and he showed that, except for a very limited area of compact form requiring a large amount of light per unit of area, this system of simple parallel distribution is impracticable on account of the enormous expense of mains to carry the large currents necessitated by the use of so low a voltage. For a very small and compact area such as a block of buildings, it may be worth while to consider the applicability of this system, however, on account of its simplicity and the cheapness of the class of cable that may be employed.

No practical use of the series system for general station work has been made that I am aware of, though, of course, it is largely in use for outdoor lighting and transmission of power. It has the obvious advantage of requiring comparatively small conductors, but against that must be put the expenditure necessary for providing a complete system of automatic cut-outs for every lamp, motor, or other apparatus employed, and the difficulty of regulating with any reasonable degree of economy for the varying numbers of lamps alight on different circuits. The comparatively

* Paper read before the Old Students' Association, December 4th, by Hamilton Kilgour, member.

low efficiency of glow lamps for series lighting is also an important reason against the adoption of such a system.

The next system to which attention may be drawn is the series-parallel system, of which the modifications known as the three-wire, four-wire, and similar systems are the most important. These are in general use both in England and abroad, and give for certain distributions of lamps a very good result indeed.

The degree of economy to be obtained with a three, four, or n wire system over the simple parallel system depends on the certainty or otherwise with which you can rely on a continued balance of load between the different sections. This you would secure as far as possible by putting as many of each class of consumers in each section, and also, if practicable, by insisting upon the wiring of all buildings supplied being upon the same system as that of the mains, and the total load in every case distributed between the sections.

If you are sure that the load in any one section will never exceed that of any of the others by more than m per cent. of the full load of a section, and the system is one of n wires; then if E stands for the percentage reduction in amount of copper used from that necessary in an equivalent simple parallel system,

$$E = 100 \left\{ 1 - \frac{200 + m\,(n-2)}{200\,(n-1} \right\}$$

For example, let $m = 25$ and $n = 3$

then $$E = 43{\cdot}8.$$

If, as in a case in which all the wiring is done upon the same system as that of the mains, we may take $m = 10$; and supposing $n = 4$, then

$$E = 63{\cdot}3.$$

If in the same case we take $n = 5$,

$$E = 71{\cdot}3.$$

In considering these systems it is necessary, in any practical case, to take into account the increased cost of labour in putting them down, and of the conduits or pipes in which they are enclosed. In connection with this, it is worthy of remark that with underground systems of mains—such as are likely to be in vogue in future—the cost of the actual cables may amount to less than 50 per cent. of the total cost of the cables laid.

With regard to systems employing accumulators or secondary generators, there is at once a great gain in the allowance of very much high pressures in the mains. The cable is, however, very much more expensive, and the cost of the accumulators and their constant inefficiency must be taken into account in the one case, and in the other the cost of the converters and their inefficiency on light loads. In the case of accumulators it is necessary to distribute the energy from sub-stations upon some one of the low tension systems, so that there is only a partial gain in respect to copper; and with converters, and especially those for alternating currents, it is well known that their cost per kilowatt output diminishes to a considerable extent as their size increases, so that with these also it may be and is advisable sometimes to employ sub-stations, so that the same remark will apply here.

I have now very briefly alluded to some of the conditions affecting the relative economies of the chief systems of distribution of electrical energy; and I have purposely refrained from examination of them in detail for the reason that every particular case will differ to some extent from any other, and in making a choice of the system to be employed to best meet its requirements, a special investigation should be made having regard to all the conditions involved.

Before taking up any problems, such as those referred to in the abstract sent out to members, a word must be said as to the relation of price to size of cable. Bare wires, as you all know, are sold at so much a pound in general; stranded cables being a little more expensive than single wires, and wires smaller than No. 20 or 22 a little dearer than those above this size. Speaking generally, however, cables of bare wire of approximately the same cross-sectional area are sold at the same price per pound. Small insulated wires of a definite thickness of insulation, such as one of two layers of cotton or silk, are also often sold at so much a pound, but with these we have nothing at present to do, unless it be to remark that with such wires the insulation resistance necessarily decreases as the wire increases in size.

Insulated cables for use in any of the cases we have to consider are, I believe, invariably sold by length.

For a given class of insulation, and a given insulation resistance per mile, you would expect—seeing that for a given insulation the mass of the insulator is directly proportional to the mass of the copper insulated—that the prices should be very nearly proportional to the cross-sectional areas of the copper conductors. In practice this is very nearly so, for the price of a cable may be expressed by the equation

$$P = a + b\,A,$$

where P = cost per mile in pounds

A = area of conductor in $\frac{1}{1000}$ths of one square inch and where a and b are constants depending upon the class of insulation and the number of strands in the cable, with considerable accuracy with the cables of some of the best known makers.

Taking Silvertown cables for example:

Class L.

7 strands	P = 10·3 + 3·58 A	within	2·6	per cent.
19 ,,	P = 15·7 + 3·39 A	,,	3·5	,,
37 ,,	P = 22·5 + 3·32 A	,,	0·7	,,

Class D.

7 strands	P = 4·72 + 1·32 A	,,	2·9	,,
19 ,,	P = 7·22 + 1·27 A	,,	4·6	,,
37 ,,	P = 12·2 + 1·25 A	,,	0·4	,,

The percentage errors given above are the maxima, and the average are from $\frac{1}{3}$ to $\frac{1}{4}$ these.

In a similar way the values of the constants for the other classes manufactured by the Silvertown Company may be tabulated, but I have not thought it necessary to do so here, more especially as I have not their most recent price sheet by me.

With Fowler-Waring cables (lead covered) you would not expect this law to hold with the same degree of accuracy, as the thickness of lead is not proportional to the diameter of the cable. We have, however, for seven-stranded cables P = 25·9 + 2·49 A, with a maximum error of 12½ per cent. and an average error of 4·8 per cent.

The cables of Messrs. Siemens are not manufactured upon the plan of having a given insulation resistance per mile for a given class of cable; the insulation resistance of their cables of a given class diminishes as the size of the cable increases. For example, for their classes L, M, and N, the insulation resistance per mile varies from 2,500 megohms for the smallest sizes to 300 megohms for the largest. You would not, then, expect to find the price of a cable proportional to its size, nor, in fact, is it actually nearly so.

With all cables, however, which are very nearly of the same size the price is, of course, very nearly proportional to the cross-sectional area of the copper, and over a narrow range the rule $P = a + b\,A$ still holds, the constants in any case being very easily determined by plotting a few points in the neighbourhood of the size you want, and drawing the tangent to the curve (or the chord through points on either side of the size you estimate is about what you require), when the ordinate of the point of intersection of this tangent or chord with the axis of y gives a, and b is the trigonometrical tangent of the angle made by the line as drawn with the axis of x, it being supposed that prices are plotted as ordinates.

Now, in any case of central station work you can estimate from experience what is approximately the cross-sectional area of copper you want, so that we may take it that, for our purposes, the rule $P = a + b\,A$ holds universally. This may be regarded in the light that you pay a sum a for the privilege of being allowed to buy the cable you require from the makers you are dealing with, and for the rest the price of this cable is directly proportional to its size.

The most economical current density to employ for a constant and uniform current circuit working for a given number of hours per annum.

Let a = current in amperes;
n = number of hours of working per annum;
ρ = resistance of conductor of one square inch sectional area in ohms per mile;
c = value of the Board of Trade unit in pence;
d = sum of the rates of interest, depreciation, and repairs on capital laid out in cable;
x = sectional area of conductor required in $\frac{1}{1000}$ths of one square inch;
D = most economical current density to employ in ampères per square inch;
$P = a + b\,x$ as before;

then $$x = a\sqrt{\frac{n\,c\,\rho}{2{\cdot}4\,b\,d}}$$

and $$D = 1{,}000\sqrt{\frac{2{\cdot}4\,b\,d}{n\,c\,\rho}}$$

For copper conductors $\rho = 0{\cdot}0425$, hence

$$x = 0{\cdot}133\,a\sqrt{\frac{n\,c}{b\,d}}$$

and $$D = 7{,}513\sqrt{\frac{b\,d}{n\,c}}$$

For example, if we take Silvertown class L cable, and

$$c = 5$$
$$d = 13$$

we shall have the most economical current densities for different numbers of hours per annum given by the following table:

n	D.		
	7 strands.	19 strands.	37 strands.
400	1,119	1,089	1,077
600	913	889	880
800	791	770	762
1,000	708	689	681
1,500	578	562	556
2,000	500	487	482
3,000	408	398	393

In this table ρ has been taken as 0·0446, which is rather higher than it should be.

No account of the increased resistance of the conductor due to heating has been taken account of in the foregoing; but as the current density to employ in a given case is known approximately from previous experience after a little, an allowance can easily be made for the probable heating in the value of ρ you decide to use.

(To be continued.)

It is a very striking example of the recuperative action of a secondary cell that you can completely discharge it, as you think, and then even charge it in the wrong direction, but it will, on being insulated, rapidly recover an E.M.F. in the original direction. Indeed, we were told of a curious case some time back. After the removal of the laboratory employed for testing ammeters from one part of a well-known London factory to another, it was found that the E P.S. accumulators always ran

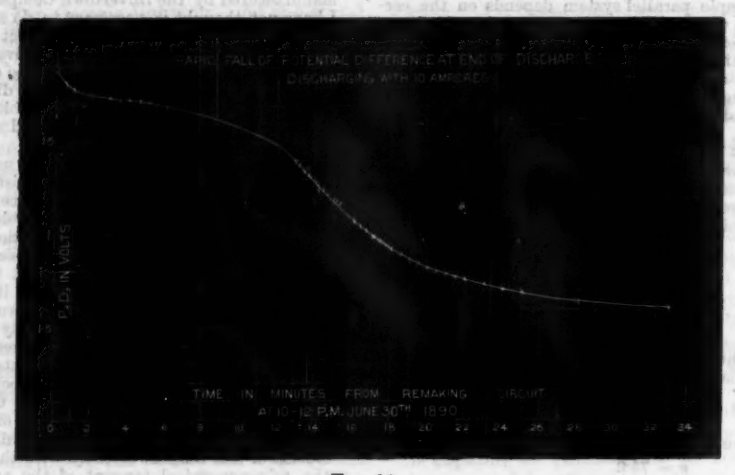

FIG. 10.

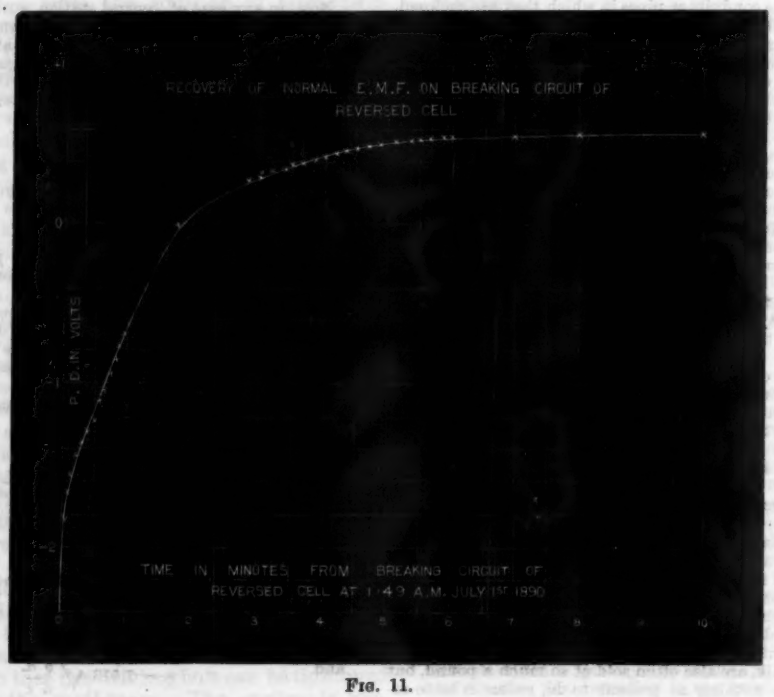
RECOVERY OF NORMAL E.M.F. ON BREAKING CIRCUIT OF REVERSED CELL
P.D. IN VOLTS
TIME IN MINUTES FROM BREAKING CIRCUIT OF REVERSED CELL AT 1·49 A.M. JULY 1ST 1890

FIG. 11.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

(Continued from page 653.)

As already explained, the constant discharge current of 10 ampères was, by the employment of some auxiliary cells, kept flowing through the accumulator under test even when its E.M.F. became very small. Towards the end of the discharge the fall of P.D. at the terminals of the cell under test became extremely rapid, so that, for example, on closing the circuit after the removal of the plugs at D' (fig. 2), the P.D. fell from 1·9 to 0·6 volts in 33 minutes, as seen from fig. 10. This rapid fall is propably due to lead peroxide being formed on the negative plates more rapidly than it could be removed by local action, since the chemical analysis showed decided evidences of lead peroxide on the plugs removed at D' from the negative plates. At E' (fig. 2) the E.M.F. of the accumulator under test became reversed, but rapidly recovered its original direction on stopping the discharge current, as seen from fig. 11.

down very rapidly whenever an attempt was made to use them, in spite of their having been charged in the intervals. As the E.M.F. was always in the right direction, it was supposed that the cells had become partially short-circuited in the removal, and it was not for some time that the true explanation of the refusal of the cells to do their work was discovered. The real fact was that, in fitting up the new laboratory, the leads from the dynamo to the switch had been reversed, so that the unfortunate cells were charged in the wrong direction every time the dynamo was turned on.

The preceding incident also forcibly illustrates the sort of attention that secondary cells may receive in practice, and shows the necessity for the P.D. and specific gravity being occasionally measured even in places where the study of the behaviour of cells is not the main business of the factory.

One of the great defects of the earlier specimens of the E.P.S. cells lay in the buckling of the plates. Mr. Capito tells us that it was Mr. Collet who noticed that all the plates generally curved in one direction, and who suspected that this arose from the unequal chemical action on the two sides of the last positive plate of the cell. Mr. Collet therefore proposed putting a negative

plate at each end of this cell, and this plan—which has been always followed since—of using one more negative than positive plate, has had much to do with removal of the buckling difficulty.

V.

EFFECT OF REST ON CHARGED ACCUMULATORS.

As the result of a number of tests described in our Edinburgh paper, we found that if E.P.S. accumulators be charged with 9 ampères and discharged with 10, a number of times without intermission, between the P.D. limits of 1·8 and 2·4 volts per cell, until the cells are brought to a perfectly steady "working state" the quantity efficiency is about 97 per cent., and the energy efficiency 87; further, that if the cells be fully charged until the P.D. per cell is 2·4 volts, and then be left perfectly insulated for 16 days, the next discharge between the fixed P.D. limits only gives out about 65 per cent. of the ampère-hours, and about 57 per cent. of the energy put in before the rest. Further, not merely is energy lost during the rest of an insulated accumulator, but for several subsequent charges and discharges between the same P.D. limits after the rest the storage capacity and the quantity and energy efficiencies are all lower than before the rest.

For the purpose of examining into what took place in an accumulator, which was left charged, a small E.P.S. cell was charged until the P.D. was 2·4 volts, and then the positive plates were withdrawn and put into another vessel containing dilute acid of specific gravity 1·2, the negatives being left in the vessel in which they were charged. Both sets of plates were covered up with gutta-percha hoods the edges of which dipped under the liquid, and to the top of each hood was fitted, gas tight, a vertical graduated glass tube closed at the top. The hoods and the glass tubes were first filled with liquid, and the amount of gas that came off from the two sets of plates was measured from day to day by watching the descent of the liquid in the tubes.

No gas was seen to come off from the positive plates, but in the case of the negatives gas came off very slowly at first, then more rapidly, and finally more slowly again. The following table gives a record of the amount of gas that came off from the negative plates, the gas, on analysis, being found to be hydrogen* :—

Hydrogen Gas Collected from Charged Negative Plates after Removal of Positive Plates.

Date.	Time.		Cubic centimetres of gas collected.	Time of collecting gas, in hours.
	H.	M.		
November 15th	11	45	0	0
„ 17th	10	0	2	46
„ 20th	12	0	52	120
„ 21st	10	0	72	142
„ 22nd	10	0	87	166

If the lead of the positive plate be turned into lead sulphate by local action, 87 c.c. of hydrogen liberated corresponds with about 0·81 gramme of lead turned into sulphate. It is clear, then, that the lead of the negative plate is steadily being turned into some oxide or salt, and probably the loss of energy which we observed in the charged cell left insulated for many days was due to this local action at the negative plate. And further, as this action takes place apparently only at the negative plate, it is clear that in the subsequent discharge the cell will appear to be discharged before the positive plate is discharged, and charged up again without reducing all the lead sulphate on the negative plate. The local action at the negative plate while a cell is standing charged has, therefore, for the first few discharges and charges after a long rest, exactly the same effect as if a portion of the negative plate had been bodily removed out of the cell. Hence we see that the peculiarities observed by us in curves 8 to 23 in our Edinburgh paper may be explained by this defective behaviour of the negative plates.

VI.

CONSTRUCTION AND FORMATION OF E.P.S. PLATES.

The question arises why the E.P.S. accumulators are so constructed that the plugs in the positive plates contain some 48 per cent. more peroxide of lead than is required to be converted into sulphate in the normal discharge. Two explanations suggest themselves. One is that, since the granules of lead peroxide begin, as we find, to be coated with a protecting coating of sulphate early in the discharge, it is impossible, with the present form of plate, for the interior of each granule of lead peroxide to be converted into sulphate, and, therefore, it is necessary to employ nearly twice as much lead peroxide as is actually needed for the chemical action. Another reason is the fear of the positive plate crumbling to pieces if it be completely formed; and this reason Mr. Capito, who was formerly in the employ of the Electrical Power Storage Company, thinks, on the whole, is the more important.

In the construction of the original Faure accumulators, as well as of the early E.P.S. cells, both the positive and the negative plates were pasted with red lead (Pb_3O_4), and formed together for a period of some 50 hours. Later on litharge (PbO) was used to coat the negative plate, red lead being used only for the positive one, and the plates were formed separately, the negative being much more formed at the works than the positive. Some time ago I was informed by a very competent authority that the following is the modern process of *forming* employed by the Electrical Power Storage Company :—

Positive Plates.—8¼" by 7¾" by ¼". Two ampères per plate, or 0·028 ampère per square inch, sent for 18 hours.

Negative Plates.—9" by 9¼" by $\frac{1}{16}$". One and a half to two ampères per plate, *i.e.*, 0·017 to 0·023 ampères per square inch, for 120 hours.

The actual time of forming either set of plates depends greatly on the length of stoppages during the formation. This is especially the case with the negative plates, therefore they endeavour to form the negatives for the 120 hours without any stoppage of the current. On the receipt of a cell from the Electrical Construction Corporation, the purchaser is requested to form it for 40 hours more with the ordinary charging current used in working, which is at the rate of 0·026 ampère per square inch.

Mr. Capito tells us that, when he was at Millwall, such periods of formation as 120 hours were not used; and he thinks that this may be due to the fact that formerly the plates were not dried after pasting and before formation, as they are at present. This drying hardens the plates and produces a better cell; but he thinks that, as the paste is itself mixed with sulphuric acid, there is probably some sulphating of the negative plates during drying, and that several hours in the subsequent formation are probably spent in reducing this sulphate.

The reason, we understand, for the manufacturers only forming the positive plates for 18 hours, and leaving the purchaser to form them for the remaining 40 hours, is that if positive plates be *well formed* and then dried for carriage, the plugs become loose, which is not the case if the positive plates be only slightly formed before drying.

We were interested in learning from Mr. Capito whether, while superintending the manufacture of many thousands of accumulator plates, he had ever tried pasting the positive with lead peroxide ($Pb O_2$) in order to avoid the necessity of having to form this salt electrically out of the red lead with which the positive plates are usually pasted. This idea of applying a paste of lead peroxide directly to the positive plate, he told us, he had tried, but that the method turned out a failure, from the impossibility of getting the lead peroxide paste to stick on to the grid even when some red lead was mixed with the lead peroxide. He also mentioned a very interesting fact—that whereas a paste of red lead mixed with dilute sulphuric acid of density 1·1 gives an adherent deposit on formation, on the contrary, a powdery deposit is produced if the density of the liquid used in making the red lead paste be 1·2. We understand the process that has shown itself the best is to use dilute sulphuric acid of density 1·1 for mixing the red lead paste, and dilute acid of 1·2 for mixing the litharge paste for the negative plates.

Discussion on "The Chemical Action of Secondary Cells," by Prof. W. E. AYRTON, F.R.S., C. G. LAMB, B.Sc., and E. W. SMITH, and on "The Working Efficiency of Secondary Cells," by the same authors and M. W. WOODS.

(*Authorised abstract.*)

In opening the discussion, Dr. GLADSTONE said he had been greatly interested in the points brought out by the authors, and in the account of the elaborate experiments described. He was rather surprised that taking out so many plugs from the cell had not greatly damaged it. The chemical results arrived at, he considered, confirmed the views put forward by himself and Mr. Tribe about nine years ago, as to the action of cells resulting in the formation and reduction of ordinary lead sulphate. Since that time, however, many statements had been made attributing important functions to sub-sulphates, but so far as he and Mr. Hibbert had investigated the matter, such statements had not been confirmed. They now believe that the so-called sub-sulphates are probably mixtures of ordinary sulphate and peroxide. Referring to the difficulty experienced by Mr. Robertson in analysing the powdered sulphate, he pointed out that ammonium acetate could be used for dissolving out the sulphate. Results obtained by this method showed the sulphate to be the normal one, and he did not think the solvent would alter any sub-sulphates if such were present. In his opinion there could be no doubt but that the sulphate surrounding granules of peroxide would act as stated in the paper and diminish the capacity of the cell. Speaking of the gas given off by the negative plate, he said the fact had been alluded to in a paper by Mr. Hibbert and himself recently published in the *Phil. Magazine*. They, however, had not observed the great differences in the hardness of plugs at different parts of the plates. This result, he considered, very important, and thought it would lead to a modification in the form of plates.

Mr. CROMPTON said that for some time past he had been working on the subject of secondary cells, and had arrived at results similar to those brought forward in the paper. One great advantage, however, of the results contained in the communications under discussion, arose from the fact that they were obtained from cells of a different type from those he had experimented on, for if he himself had brought the results before the Institution, it would have been thought that the actions were peculiar to his kind of cell. As regards the "gassing" of cells, he had found it due in a great

* Since the preparation of this paper we have noticed that Dr. Gladstone and Mr. Hibbert, in their paper communicated this summer to the Physical Society, have also observed that hydrogen comes off from a charged negative plate of a secondary cell when left idle.

measure to light. Both sunlight and arc light increased this action, and quantitative experiments were now being made. He was glad to see the statements of the advocates of secondary batteries, as regards efficiency, had been confirmed. They had, he said, been accused of exaggerating their efficiency, and not without cause, for the cells themselves behave peculiarly, as, for example, the 105 per cent. quantity efficiency mentioned in the paper. Such results seem impossible, and showed the necessity of getting cells into what the authors had called "the steady working state." He regretted that "proof plates" had not been used in the experiments on the running down of cells. He had used them for a long time, and always found the negative discharged first. If, however, very thick negatives were used, there was no sudden drop in the potential difference such as indicated in figs. 2 and 3. In endeavouring to measure the resistance of cells with a view to determining the best proportions of plates and liquid, he had met with great difficulties, and he now believed that what is usually measured is of the nature of a back E.M.F.; this he supported by saying that the so-called resistance did not seem to vary either with the thickness of the plates or their distance apart, or with the density of the acid. During his investigations a rosy colouration of parts of the liquid had been noticed in some cells; the coloured portions may either appear as strata, lines, or in tree-like forms, and in some cases resemble the shapes of magnetic lines of force. These peculiarities, he hopes, may give some idea of the electric stresses and strains within the electrolyte. The recuperative power of discharged and reversed cells was very marked, for he had observed it in cells that were half charged in the reverse direction, and on cutting up the plates, layers of different materials could be seen. This fact shows how important it is to thoroughly charge cells of the Planté type during formation by reversals. Until quite recently, negative plates had been considered faultless, and the positives blamed for defects which were in reality due to imperfections in the negatives. He knew of no case in which positives had gone bad when their negatives had sufficient capacity; and for this reason the negatives ought to be made thicker or larger than the positives. "Sick cells," he said, get partially sulphated and the negatives run down; when the E.M.F. falls below 1·3, heavy sulphating of the positive occurs, and so-called "irreducible sulphate" is formed. In his opinion the reducibility or irreducibility is merely a question of its position, or of its contact or want of contact with the conducting material. In conclusion, he suggested that E.P.S. cells might be improved by reducing the size of the plugs so as to bring the active material down to the lead backing.

The discussion was adjourned to the 27th inst.

NOVEMBER 27th, 1890.

Mr. CROMPTON directed attention to three diagrams which he had prepared since last meeting. One of these showed the character of the colouration seen in the electrolyte when viewed from the top curved lines or shells, start from the positive plates and turn away as if repelled from the cell terminals. In one cell, which had its + and − terminals at opposite ends, the lines curved towards the middle of the cell, whilst in another, where the terminals were both at the same end, they bent towards the opposite end. The second diagram exhibited the influence of the rate of discharge on the capacity of a cell having eleven 5 lb. plates. When discharged at 1 ampère per plate, its capacity was 300 ampère hours, but at 6 ampères, only about half. The fall of volts was very sudden at the end of each discharge. The third diagram related to the discharge of an experimental cell containing seven 9 lb. plates, and showed that although the capacities were not very different from those of the 11 plate cell, the fall in volts was not nearly so sudden.

Mr. RECKENZAUN said the papers under discussion were very important ones, and contained much that had never been published before; many of the facts, however, were known to those engaged in the manufacture. The question of efficiency, he thought, was not likely to be settled, since, according to the authors, it may vary between 105 and 58 per cent., depending on the previous history of the cells. In his own experiments on the effect of prolonged rest, he had found a similar loss of efficiency, and he believed this to be due to sulphating of the negatives. The negatives were always played out first, and this defect could not be got over by making them abnormally thick, or by increasing their surface; for if thickening be tried, the interior is not acted on, whilst greater surface gives no advantage on account of the material being at different distances. To test the deficiency of negative plates, he had discharged cells as low as possible, and then put the positive with a newly charged negative; from these a fair E.M.F. and discharge were obtained. He had also tried amalgamated zinc instead of a newly charged negative, and got 40 per cent. of the original capacity. These facts account for the existence of 30 per cent. of PbO_2 in the positive plugs when the cell was supposed to be completely discharged. In his opinion it would be better to say that the negatives discharged about 30 per cent. too soon. The negatives of Planté cells, especially those formed by the nitric acid process, soon lose their virtue, and this was attributed to the difficulty in removing all the forming acid. In the course of his remarks Mr. Reckenzaun said he had received a very interesting diagram from his brother in America, showing the E.M.F., current, density of acid, temperature of cell and of surrounding air, &c., during the charges and discharges of a secondary battery; this diagram he would place in the hands of the secretary.

A communication from Mr. HALL was then read. This related to a pair of E.P.S. plates recently taken from the battery under his charge at the P. and O. Company's offices, where they had been in constant use for 6 years. During that period the cells had supplied about 150,000 ampère hours and were still in good condition, as was indeed evident from the appearance of the plates shown. In the working of the battery, the density of each cell had been carefully watched, and any defect promptly removed. His experience confirmed the observations of the authors on the effect of rest.

Mr. W. HIBBERT referring to the Edinburgh paper said he would first deal with the explanation of the high E.M.F. at the end of a charge, and its rapid fall on breaking the circuit. In a communication made to the Physical Society last June, Dr. Gladstone and himself had shown reason for believing this to be due to concentration of acid about the positive plate and subsequent rapid diffusion, and he thought the results plotted in fig. 6 of the paper under discussion, showing the effect of making and breaking the circuit of a charged cell on its E.M.F. and P.D., were consistent with this idea. Further on in the same paper the authors say that the concentration hypothesis will not explain the rise of P.D. in a cell discharging after a long rest; on this point he, Mr. Hibbert, said that the reactions in such states were very complex, but still he thought it would be possible to find an explanation of this phenomenon based on similar lines. Referring to the latter paper, he thought the authors had rather exaggerated the effect of peroxide on the negative plate in causing the volts to fall, for in his own experiments only a small quantity was formed. The simultaneous weakening of the acid round the plates would tend to give a rapid fall in the E.M.F. and the effect of both these actions must be studied if the subject is to be properly understood.

Dr. E. FRANKLAND said he had read the papers with great interest and considered them most important contributions on the subject. In one place the authors deplore the lack of knowledge of the chemical action in cells, and not without reason, he, however, thought physicists were more to blame than chemists, for the physical actions could be readily determined, whereas the chemical changes present formidable difficulties. The substances used and produced were mixtures, and it was very difficult to separate and analyse them, without producing decompositions. A valuable part of the communication was that relating to the quantity of PbO_2 formed and decomposed during the working of cells. On this point he thought the values put down for PbO_2 may be either the sesqui-or the three-quarter-oxide, and, in fact, the crux of the whole subject lay in the exact nature of the compounds formed. Dr. Gladstone and himself had apparently arrived at different conclusions, but their differences might admit of explanation, if care and time were taken in considering the matter. Another important point was the quantity of SO_2 absorbed during discharge, viz., 3·08 grammes per ampère hour. If this be translated into hexabasic acid, which he believed to be present, it gives 5·71 grammes. From his own experiments on a 10-plate cell, he had found about 4·7 grammes of hexabasic acid absorbed per ampère hour, whilst discharging at an E.M.F. averaging 1·9 volts, but when the cell was run down and discharged at an E.M.F. averaging 0·3 volt, he found the rate about 3·3 grammes. He did not wish to put these numbers in conflict with those obtained by the authors, but he was strongly impressed with the idea that the two different quantities 4·7 and 3·3, pointed to the existence of two distinct chemical reactions, one resulting in an E.M.F. of about 2 volts, and the other of ·3 volt.

Mr. F. KING said the results of the tests were very gratifying to the makers of cells. He commended the skill and ingenuity displayed in devising the automatic apparatus, for the labour involved in working a laboratory day and night without such apparatus is enormous. The inequality of current distribution over the surface of the plates was, he said, well known, and the hanging type of cell was devised to remedy this defect. The first form of this type was abandoned, but more recently they had made another form, one of which was exhibited at the meeting. The current is led into the positives at two points on the top and leaves the negatives at the bottom. With this cell they had doubled the normal rate of discharge without diminishing the capacity and also obtained a longer life. Moreover, the loss of capacity for high rates of discharge, due to the shrinkage of the negative paste and which is so marked in ordinary types, had been avoided. The positive plates somewhat resemble those of the Tudor cell, having deep horizontal grooves along each side in which the active material is placed. The negatives are made according to Sellon's invention, in which a kind of double grid is used, the parts being displaced diagonally so that each plug on one side communicates directly with four plugs on the opposite side and through them with every other plug in that division of the plate. This construction causes any shrinkage of the paste to bind itself more firmly on the grid. As a result of tests on the new cell it has been found that the capacity is greater after 500 or 600 discharges than at the beginning, whereas that of ordinary cells is considerably reduced by 400 discharges. The life of negative plates he believed was not well understood, but with reference to positives he said that those used on tramcars (nine plates 8" × 9½") had a useful life of 70,000 ampère hours. After one year's use their capacity is reduced 83 per cent. Speaking of the resistance of battery connections, he pointed out the advisability of burning the lugs together so as to give as complete a metallic surface as possible. Respecting the pasting and formation of E.P.S. plates, referred to in the second paper, he said that the particulars there given were totally wrong.

Mr. SWINBURNE thought there had never been any solid reason for doubting the formation of normal lead sulphate. The old

ideas about reduction and oxidation that had obscured the subject until Dr. Gladstone and Mr. Tribe brought people to order about eight years ago. The difficulty of reducing ordinary sulphate electrically had been given as a reason why it could not be formed, but now its reduction or non-reduction was known to be a mere question of making contact with it. Seven years ago he had brought forward a theory that the sulphate is not a secondary product at all, and that the output of a cell is mainly dependent on the affinity of sulphion for lead. This, together with the other chemical actions, leaves some E.M.F. to be accounted for by Peltier effects, and these effects would show in the temperature coefficient. He was not aware whether calorimetric data had been obtained for the subsulphates which Dr. Frankland supposed to be present, but, if so, then by working backwards evidence for or against their existence might be procured. The action of finely divided lead on sulphuric acid had, he had, been known for years, and this limited the best strength of acid to about 1 in 4. As regards the equilibrium between the plates of a cell, he was inclined to attribute this either to the absence of $Pb O_2$ from the positive, or of spongy lead from the negative, rather than to the presence of $Pb O_2$ on both plates. He also thought the percentage of material really active was much less than that stated in the paper, for in some experiments of his own he had only found about 8 per cent. useful. Speaking of Mr. Crompton's colour observation, Mr. Swinburne said they were due to ferric acid formed by the action of $Pb O_2$ on iron salts in the commercial acid. In his opinion the virtue of sulphate of soda had been greatly exaggerated, and he believed its action to be due to its enabling bad contact sulphate to be reached more easily.

Sir D. SALOMONS said he had noticed colouration in one or two of his cells, but had attributed them to impurities. The unequal action on different plugs had been to him a subject of common remark, and he had taken steps to equalise the distribution of current by burning on strips of lead, with good results. The bending of negatives could be prevented by building up the sections rigidly. His experience with soda differed from that of Mr. Swinburne, for he had found caustic soda, in the proportion of one ounce to six gallons, very advantageous. Cells supplied with this electrolyte had been left charged for six weeks without injury, and had commenced to boil freely ten minutes after the charging current was started. With ordinary acid, two or three hours charging would be required to produce the same results. In his opinion, makers give extreme limits for the so-called normal working rates of cells, and if these were divided by 2 or 3, better results would be obtained, and would be cheaper in the long run. As regards efficiency, he thought 70 per cent. to be a very fair average. The large amount of $Pb O_2$ not acted on, resulted from the interior of the plugs being, as it were, waterproofed by the sulphate outside. On this account thick plates possessed little or no advantage. Increasing the quantity of electrolyte, however, gives more capacity up to a certain point, but when the plates are put far apart the loss of volts becomes serious. Speaking of pasting positives with $Pb O_2$, he said he had made good plates in this way by using very strong acid (nearly pure) in making the paste.

Mr. BERNARD DRAKE, whilst adding his testimony to the value of the papers, thought he ought to mention one or two points of detail which might lead to wrong conclusions. For example, the loss of efficiency due to rest might lead clients to suppose that their cells ought to be used even when they were away from home. This, he said, would be a great mistake, for the loss of capacity is due to the negatives; whereas the repairs were chiefly restricted to the positives, whose lives are inversely proportional to the amount of use. In a paper read before the British Association in 1886, he and Mr. Gorham had shown that the whole success of storage cells depended on whether the positives could be made to last a reasonable time, and to effect this it had been found necessary to overcharge them. The actual plates sent by Mr. Hall from the P. and O. offices had been badly sulphated some time ago, and were condemned; he, however, recommended overcharging, with the result now known. In these cells the density of acid used to be from 1,350 to 1,400, and although he did not now recommend such a high specific gravity, yet he thought the subject required more attention than it had received. As to the proportions of the plates, he said the negatives were intentionally made to give out first, so that the positives might not be run down, for a kind of protecting coating is formed on the positives by charging and this is removed by discharging them below a certain point. If this coating is continually reformed the plates expand and buckle and the plugs eventually drop out. Speaking of the cooling action during discharge and also after charging has commenced, he did not see any explanation excepting perhaps that it might depend on the same cause as the rise of specific gravity which occurs after a charging has stopped. This he had found to be due to the heavy acid formed during charging falling to the bottom of the cell and afterwards diffusing into the general body of the liquid, thus affecting the hydrometer. In this connection he enquired whether the temperature was taken at the top or bottom of the cells. The rise of E.M.F. during the first part of a discharge after rest he attributed to the surface of the negatives being coated w th a sulphate which was reduced by the discharging current. In reference to the shrinkage of negatives mentioned by Mr. King, he said that in order to avoid blistered negatives a mixture of litharge and sulphate had been used for pasting instead of litharge only. This method although it prevented blistering, necessarily left the plugs of a porous nature, and was liable to permit shrinkage.

The discussion was adjourned to the 11th December.

LEGAL.

Watt v. Maxim-Weston Electric Company.—The matter in dispute between Mr. Watt and The Maxim-Weston Electric Lighting Company were at last settled, on Monday last, by arrangement between the parties. Mr. Watt had claimed £1,623 for salary, commission on the profits of the company, compensation for wrongful dismissal from his position of managing director, payment of rent, and other moneys. A cross action was brought by the company, and it was alleged that Mr. Watt had been general manager upon whose representations the other directors and the auditors relied, and that the accounts purporting to be profit and loss were made out by him. It was also stated that these accounts were untrue, having been made to appear as large as possible so that he could draw 5 per cent. commission, and that upon them plaintiff received larger sums than he was entitled to. Further, it was alleged that he had sent out goods to agents abroad which were not sold, but which were treated by plaintiff as actual sales, and also that bad debts had been entered as good. At Mr. Justice Romer's suggestion the two actions were treated as one and tried together.

The hearing of the case lasted three days, and the judge finally suggested that this was a case where, instead of going through the items one by one, a general sum should be arrived at between the parties, and proposed that he should rise for a short time with a view of counsel seeing whether that could be done.

Counsel on both sides assented to the suggestion, and, after an absence of half-an-hour, his lordship returned into Court, when

Mr. Rigby announced that they had arranged everything as between the company on the one side and Mr. Watt, whether properly raised in actions or not. Watt was to pay the liquidator certain sums standing to his credit in respect of shares purchased by the liquidator, and £330 14s. which stood to a joint account, would be paid to the company, together with the sum of £669 6s. standing to a joint account, and making up £1,000. The actions had got very much mixed up together, but Mr. Watt would pay the taxed costs between party and party in both actions. Mr. Watt would not pay any costs in the winding-up, but included as proper costs in the action were the costs of the motion, directed by the Registrar. The matter was a final settlement of all claims down to this date between the company and the liquidators on the one side and Mr. Watt on the other, whether properly raised in these actions or not, so as to prevent any further litigation.

REVIEW.

Electric Light, its Production and Use; Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By G. W. URQUHART. Fourth Edition. London: Crosby, Lockwood and Son.

The third edition of this work was noticed by us in January of this year, and in reprinting a fourth, the opportunity has been taken of adding two new chapters, "Notes on Ship Lighting," and "Electric Light Wiring Tests." Twelve new illustrations have also been added. Mr. Urquhart's books are written for workmen, and like most works of the kind, are not free from errors, when judged from a scientic standpoint. They are, however, better than most popular works of the same class. Referring to the new chapters, the author's ideas of insulated cables are decidedly crude, and his descriptions of the methods of testing are not likely to afford much help. A mistake is made in explaining the lamp test for earth leakage. We fear that a good deal of the information in these chapters has been derived from published papers and articles rather than from practical experience.

Obituary.—M. A. Bède.—We regret to announce the death, in Brussels, of M. Armand Bède, son of M. E. Bède, the well-known Belgian electrician and engineer. The deceased was one of the most distinguished engineering students at the Brussels Polytechnic School, and had already made himself a name by important electrical installations in Russia and Italy and also in Belgium, where he was obliged to return three years since on account of weak health. This gentlemen's death is the cause of much sympathy among Brussels engineers, who had for several years unanimously elected him their vice-president.

ELECTRIC LIGHTING PROGRESS IN LONDON.

THE paper on this topic, read by Mr. Frank Bailey, before the Society of Arts, is a summary of the present position of things. The paper contains a general history of electric lighting in London, with details of systems adopted. Private plants work about 80,000 32-watt lamps in addition to the supply companies. Mr. Bailey showed the first lamp made by Edison and by Swan, some drawings of the stations, the ratio between maximum lamps supplied and lamp connections at most of the stations, the average being about 50 per cent., and curves showing the daily output. The following table, a copy of which Mr. Bailey has kindly sent us, will be found very interesting :—

ELECTRIC LIGHTING COMPANIES IN LONDON.

	Name of company.	Capital (nominal).	Number of years in existence.	Stations.	Total H.P. engines.	Number of lamps equivalent to 32-watt lamps now connected.	System.	Length of conduit, pipe, or single run of main.	Lamps per mile.	Meters.	Districts.
St. James, St. George, Chelsea, Rotherhithe, Bermondsey, St. Mary, Newington, Lambeth (part of), St. Martin's-in-the-Fields (part of). Bill, 1889 ...	Lond. Electric Supply Corporation., Limited	£ 1,250,000	5	Deptford		38,000	Alternate current	Miles ...	...	Number. Type. 136 Ferranti (mercury)	Parishes of :— Clerkenwell (part of) St. Martin's
St. Margaret and St. John, Westminster—Greenwich dis.	... ...	...	...	converting stations	... ...	...	transformers (Ferranti)	...	...	174 Ferranti-Wright-Borel	
St. Olave's district	... ...	...	...	... ...	... ...	...	... ...	...	...	14 Frager	
St. Saviour's district	... ...	...	...								
The Board of Works of St. Giles' district, Holborn district ...	Metropolitan Electric Supply Co., Limited	500,000	2½	Whitehall	600		Direct current & batteries	...	...	... ...	
Strand district, 1889	... ...	...	...	Sardinia Street	3,000	44,598	Alternate current trans. (Westinghouse)	...	1486	378 Schallenberger	Mid. London Or.
Parish of St. Marylebone, 1889	... ...	...	...	Rathbone Place	1,200		,, (Parker)	...	...	25 Aron	W. London Order
,, ,, Paddington, 1890 ...	... ...	...	...	Manchester Square	2,000		,, ,,	...	...	... ...	Paddington Or.
St. Mary Abbot, Kensington—2 portions of	House-to-House ...	350,000	2	West Brompton	600	12,898	,, Lowrie-Hall	8¼	1517	71 Lowrie-Hall 168 Westinghouse	Parish of
Belgravia and Mayfair	Westminster ...	214,765	2	Millbank Street	temporary station now in progress	7,540	Direct current & batteries	...	...	93 Aron	Westminster
				Dacre Street	,, ,,		,, ,, ,,	...	...		
				Eccleston Place	,, ,,		,, ,, ,,	...	...		
				Davies Street							
Kensington and Knightsbridge	Kensington and Knightsbridge ...	300,000	4	Kensington Crt. Chapel Place	1,560 and Howell Bttrs.	24,850	,, ,, ,, (Crompton)	10¼	2366	200 Aron 90 Hookham 34 Aubert	Central
St. Mary Abbot, Kensington—portion of	Chelsea Electric Supply Company	108,000	6	Draycott Place and 3 distributing	Batteries, E.P.S. stations	19,500	Direct current & batteries (King)	... as published in		... ... the *Engineer*, October 24th, 1890	Parish of
St. Mary Abbot, Kensington—portion of	Notting Hill ..	100,000	1	High Street	nearly complete	and another	station not yet commenced	...	...	... ...	,,
St. James'...	St. James' & P. Mall	100,000	2½	Duke Street	1,960	23,174	Direct current	4½ miles	5452	190 Aron	,,
St. Pancras	St. Pancras Vestry	...	...	Stanhope Street	now in progress		,, ,,	...	...	... ...	,,
St. Martin's-in-the-Fields ...	The Electrical Supply Corpratn., Lt. (formerly Messrs. Gatti)	...	...	Strand	658	8,500	,, ,,	...	...	— Frager	,,
					Total	179,060 lamps equivalent to 32 watts each.		...			

PARLIAMENTARY NOTES.

Railway Signalling.

IN the House of Commons, on Friday, in reply to Captain Price, Sir M. HICKS-BEACH said: The subject of automatic electric signalling on railways has frequently engaged the attention of the Board of Trade, and further inquiries are now being made. There are many difficulties to be contended with, and all I can say at present is that the matter will continue to receive attention. It may be added that the Norton-Fitwarren collision would not have been prevented had the system, as hitherto carried out, been in force there.

Licences for Telephone Exchanges.

In the House of Commons on Monday, Dr. CAMERON asked the Postmaster-General whether, in view of the fact that the patent for the telephone in use by the company which possesses a practical monopoly of telephonic communication in Great Britain had now expired, and in view of the numerous complaints on the part of the public as to high rates and faulty service resulting from that monopoly, he would, with as little delay as possible, make known his decision as to applications for licenses submitted to the Post Office by proposed competitors desiring to introduce loud-speaking and long-distance telephones, and other forms of improved instruments.

Mr. RAIKES: In reply to the hon. member, I have to say that I trust that I may be able at an early date to announce the decision of the Government with regard to licenses for telephone exchanges. It should be borne in mind that the patents for the more important telephones have not expired, and do not expire until July in next year.

Electric Lighting in London.

Mr. R. CHAMBERLAIN asked the President of the Board of Trade whether his attention had been called to the long-continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence; and whether he would take steps to compel this company to keep faith with the public or forfeit their concession.

Sir M. HICKS-BEACH: Last winter the hon. member complained to the Board of Trade of the deficiency in the standard pressure of the current supplied by this company. The Board of Trade communicated with the company, and were informed that the cause of complaint had been removed. Under the regulations imposed upon the company under their order they are bound to declare to the consumer the constant pressure at which they propose to supply him with energy, and the variation from the pressure so declared must not exceed 4 per cent. under a penalty not exceeding £5 for each default, and a daily penalty not exceeding £5 so long as the default continues. If the regulations are not complied with, it is open to the consumer to proceed against the company for penalties.

Mr. R. CHAMBERLAIN asked whether the right hon. gentleman's attention had been called to the fact that the variation mentioned was taken advantage of in order to supply the consumers, not with an average of 100 volts, but of 97, in that way taking advantage of the concession of the Board of Trade.

Sir M. HICKS-BEACH: However that may be, if the company are in default, the consumers have their remedy. It is not for the Board of Trade to enforce the law.

Mr. R. CHAMBERLAIN: I understand from the right hon. gentleman that we have no remedy unless they get below 96, the 4 per cent. referred to in the answer just given.

Sir M. HICKS-BEACH: Yes, sir, that is so.

Lighting of Friedek.—The streets of this small town in Eastern Silesia were lighted electrically for the first time on the 12th ult.

NOTES.

The Paris-London Telephone Line.—It is announced that the cable will start from the French coast near Calais and terminate at Dover, from which town the line will be carried overhead to London. The apparatus in Paris will be provisionally installed at the Bourse, and will subsequently be erected permanently in the Hotel des Telephones in the Rue Gutenberg as soon as that building is completed. The telephone will be available for use both day and night, including Sunday, notwithstanding, as a French paper says, "the rigorous English custom which desires all work to repose on that day." It is believed that the charge for conversation will not be less than 20 francs for five minutes. If all goes well, the line is to be opened on the 15th of February.

Count Mattei's Coloured Electricities.—A friend writes:—"Referring to the remarks in your journal of 28th ult. on Count Mattei's remedies, you are wrong in thinking that the Count attributes any of his undoubted success to electricity. He certainly calls his system "Electro-homœopathy," but merely because many of them are quick in action as compared with homœopathy proper, but has nothing whatever to do with actual electricity. I think it is a pity to condemn a system which possibly may have some merit—merely on an erroneous idea."

Portsmouth New Town Hall.—The Portsmouth New Town Hall, which has cost £140,000, has an installation of the electric light, and the illumination of the large hall, in which Madame Patti sang on her recent visit to the town, has given great satisfaction. In order to provide efficiently for charging the accumulators with electricity, the Town Hall Committee have been advised that another dynamo should be erected. The tender for this dynamo was £260, but as there will be some other work connected with it, the Town Council at a meeting last week authorised the committee to expend a sum not exceeding £300.

Lacombe and Company.—Mr. Holland Dell announces that in consequence of increase of business, Messrs. Lacombe & Co. have taken ground-floor premises at 7, Carteret Street, Westminster, where a sufficient stock will be kept of carbon goods to meet pressing demands at short notice. Attention is drawn to the fact that Messrs. Lacombe & Co.'s works have been enlarged, and the plant increased.

Glasgow Telephone.—The new directory of Glasgow subscribers to the National Telephone Company is just published, and contains a notice that on and after the 1st January next the existing rate of £15 per annum for the first connection to the exchange, within the half mile radius, will be reduced to £10. Subscribers private houses, if within a radius of one mile from the nearest switch room, are connected for an annual charge of £8 10s.

Engineers' Pocket Books.—We have received copies of the following publications for 1891.—"The Practical Engineer Pocket Book," published by the Technical Publishing Company, Manchester; and "The Mechanical World Pocket Book," published by Messrs. Emmott and Co., of Manchester and London. Bo contain a number of tables and items of information th the greatest service to engineers, mechanics, draughtsmen, and others.

The National Telephone Company and Mr. Erskine Muirhead.—We have received some further letters from Mr. Muirhead, but as they do not contain matter of interest we must decline to print them, and must close the correspondence, which reveals a state of affairs, on the one hand decidedly high-handed, and on the other decidedly deficient in dignity of tone.

Photography.—According to the *Amateur Photographer*, Sir David Salomons, Bart., takes a great interest in photography, especially in connection with the Tunbridge Wells Amateur Photographic Association.

Telephony between Germany and Switzerland.—Political difficulties have hitherto prevented the establishment of telephonic communication between the towns on the Swiss-German frontier. These obstacles have now been removed, and telephonic lines will shortly be erected.

High Pressure Alternating Mains.—*Industries* says: "Reports have of late been freely circulated that the Deptford electric light mains show a very much higher pressure at the London than at the Deptford end. Several eminent scientific men are said to be investigating this phenomenon. We should like to know more about this apparently impossible effect. We may mention another fact, which may be foretold on theoretical grounds, and which, while being apparently similar, is really quite different from that referred to above. For example, if a dynamo is excited to give, say, 5,000 volts at the terminals before the mains are connected, it will give considerably more directly they are thrown on, especially if the load is very light, but the increased pressure will be at Deptford as well as in London. The rise of pressure can be roughly calculated beforehand if the particulars of the dynamo and mains are given. A higher pressure in London than Deptford at a given time appears quite incapable of explanation with our present knowledge."

Tapping Holes in Porcelain with Fine Threads.—Messrs. Taylor, Tunnicliff & Co. send us the following note:—"Messrs. Bullers appear to have misconstrued the remarks on the above question in your issue of November 14th. It is well known that coarse threads in porcelain have for a considerable time been made in large quantities by the various firms engaged in the trade; but the finer pitch of Whitworth threads of $\frac{1}{16}$th to $\frac{1}{4}$th diameter are but of very recent introduction, and present considerable difficulty in production in the stereotyped methods, as well as uncertainty in the finished articles. All we claim is that we have invented a machine which ensures a solid thread of fine pitch and regularity of size, much superior to the ordinary hand-made article. We do not think Messrs. Buller will deny that this requirement is of but recent introduction, and has not been in use the number of years their remarks would have you to suppose."

Electropathic Belts.—It is surprising to find papers, edited by men who have graduated at Oxford or Cambridge, allowing their columns to be prostituted by the advertisements of so-called medical electricians. The *Whirlwind*, the organ of the Hon. Stuart Erskine and Mr. H. Vivian, contained on the 22nd ult. what, at first sight, appeared to be an article referring to the Rev. E. F. Shaw. The eighth line, however, showed conclusively that the article, which was prominently given on the front page of that paper, was only an advertisement of the "Eminent's" electropathic belts. The editors of the *Whirlwind* cannot be congratulated on the results of their schooling.

Recent Interruptions and Repairs to Submarine Cables and Land Lines, up to 25th November, 1890:—

Cables.	Interrupted.	Repaired.
Suakim—Perim	12th Sept. ...	Still interrupted.
Cape St. Jacques—Thuanan	21st Oct. ...	27th Oct.
Porthcurno—Vigo	1st Nov. ...	20th Nov.
Vigo—Lisbon...	1st Nov. ...	17th Nov.
Mozambique—Louvenço-Marquez...	11th Nov. ...	11th Nov.
Mozambique—Louvenço-Marquez...	18th Nov. ...	19th Nov.
Trinidad—Demerara ...	18th Nov. ...	Still interrupted.
Salina Cruz—Libertad ...	25th Nov. ...	" "
Land-lines.		
Moulmein—Bangkok ...	22nd Oct. ...	24th Oct.
" " ...	9th Nov. ...	10th Nov.
Dakar—Yof	27th Oct. ...	29th Oct.

The Electrode.—Mr. D. Hillock, of 58, Berners Street, W., believes he has made an important discovery. He advertises "The Electrode," by the use of which "the blind recover their sight, the deaf their hearing, and those who have lost their voice regain it." Electricians do not see, neither do they wish to hear, but they raise their voices to protest against the use of such bogus statements.

The City Lighting.—Why the City papers and others grumble about the delay in the electric lighting of the City cannot be imagined. A man or a company is not likely to complete a contract before the close of the stipulated period without receiving some pecuniary benefit; and yet people talk about the "knowing City men."

Reduced to the Ranks.—Mr. J. Swinburne has lost his German "professorship," which he only recently gained. The *Elektrotechnische Zeitschrift* has been pleased "to undress" the (word) "professor."

Fire Brigade Failings.—A representative of *Trade, Finance, and Recreation* has had an interview with Captain Arthur Shean on "Fire Brigade Failings." We are acquainted with Captain Shaw and with Mr. Simmonds, his second in command, but we scarcely think that the author of the following remarks can be attached to the London Fire Brigade; if so, he might with advantage take a course of lessons on elementary electrotechnics at one of the technical colleges:—Q. "Have the fire brigade any special method of dealing with fires caused by the imperfect insulation of the electric light?" A. "No, they have neither received any instructions with reference to the matter, nor been provided with proper implements. A man ought not to cut an electric wire with an ordinary hatchet unless he wears an India-rubber glove, and yet such a glove does not exist in the whole brigade. I was at a theatre the other night which is lighted with electricity, and I asked the fireman what he would do if the electric light were to ignite any part of the building? I was astonished to find that he knew nothing about it, and that there was nothing in the theatre in readiness for such a calamity. One of these days we shall have a great sensation, because a fire caused by electricity is more serious than an ordinary fire, *since you have the ignitable force fitted all over the building.* Up to the present there have been several accidents in London through electric lighting, and surely we ought not to wait till some great disaster occurs before attending to the subject." What does the gallant Captain mean by the ignitable force being fitted all over the building? Is not gas fitted all over a building, and when a rupture occurs in an electric conductor does not the ignitable force vanish at once?

Guaranteed Accumulator Maintenance.—The General Electric Power and Traction Company, Limited, is now offering to tramway companies to supply cars and the electrical equipment, and to *maintain* the motors, swithches, gearing, and accumulators at a mileage rate; the tramway company operating the road at their own expense. The result of the experience at Barking enables this company to undertake electric plant maintenance at such a price that, including the cost of generating the power, &c., traction by accumulator cars will be less costly than that of horses; and in northern towns, where coal is cheap, the cost will be much below that of horse traction. A recent improvement in the "E.P.S." accumulators warrants the statement that this form of traction on average roads must of necessity be in all cases less than that of horse traction. The company is at present in negotiation with some of the largest tramway companies in the country on these lines. The company is also busily employed in the manufacture and erection of mining plant for many of the principal collieries in the country. This branch of the work is rapidly developing.

Tramway Companies and Electric Traction.—The North Metropolitan Tramway Company has received the consent of the London County Council to run electric cars over the northern portion of its line, controlled by the Council, during the term of 7 years. The tramway company has also given notice of a Bill which it intends to introduce into Parliament, asking Parliament to compel the local authorities to conform to the Act as passed last session, giving the tramway company the full term of seven years guaranteed by the Act. At present, the West Ham local authorities decline to grant more than one year's license, subject to 24 hours' notice. It is, hoped, however, that they will now follow the example of the London County Council, and grant the full term of the license, enabling the tramway company to equip two roads on which their lines run, and which are in the parish of West Ham, and on which it is the intention of the tramway company to place electric accumulator cars.

Automatic Fire Alarms.—On Wednesday, December 3rd, there took place in the arsenal of the Great Lake, Genoa, in presence of the territorial director and vice-director of artillery and of various officers of the artillery and the military engineers, the first experiments on the auto-electric fire alarm and signal thermometer on the Bieberstein-Fois system, which the inventors offer in homage to the king. The experiments succeeded surprisingly: the apparatus combined the sensitiveness of the mercurial thermometer and gave instantaneous alarms at whatever temperature, which result is due in part to the excellent workmanship of the establishment for instruments of precision, A. E. Conti (Sant Algo, Genoa), which may compete for such kind of work with the first foreign houses.

Ironmongers and Sale of Electrical Fittings.—Our contemporary *Ironmongery*, "to give further effect to oft-repeated counsel that ironmongers should take up electrical fittings as a substantial branch of the trade," purpose commencing in the January number a series of practical articles on electric installations, for the guidance of those who intend taking up the sale of electrical accessories.

The London Electric Supply Corporation. — We understand that Mr. Ferranti has shut off the supply of electrical energy to the customers of this corporation, and that it may be two or three weeks before the current will be turned on again. We believe that the mishap, to which we refer in our leading pages, is mainly the cause of this temporary stoppage. With the apparatus once again in working order, Mr. Ferranti does not intend to allow a recurrence of the recent disaster.

Underground Cables.—We have received two important communications bearing upon the letter in our last issue, "Notes on Electric Lighting from Central Stations." The first is from Mr. Alfred E. Mavor, general manager to the Fowler-Waring Cables Company, and the second is penned by Mr. Ferranti, and both give direct denials to the statements contained in the copy of the India Rubber and Gutta-Percha Company's letter. We shall publish these in our next issue.

A Correction.—In our note on Theatre Lighting last week we should have stated that Messrs. C. E. G. Gilbert & Co. had secured the contract for lighting the Globe Theatre, the name of Messrs. Dickinson being an error.

Montevidean and Brazilian Telegraph.—An extraordinary general meeting of the Montevidean and Brazilian Telegraph Company, Limited, was held on Wednesday at Langthorn House, Copthall Avenue, Dr. Cameron, M.P., presiding, when resolutions passed at an extraordinary general meeting held on November 25th, and reported in our issue of November 28th, were confirmed.

Popularising the Telephone.—The *City Press* says: "With the New Year it is understood that the Post Office authorities will make new arrangements for the public use of the telephone, tending to popularise the instrument and bring it into general employ." We understand that no important step will now be made by the authorities, at least until after the transmitter patent of Edison expires next July.

Marriage of Captain Khotinsky.—The marriage of Captain A. de Khotinsky, of Rotterdam, the inventor of the Khotinsky electric system, with Mrs. M. Fuller, widow of the late P. Fuller, Esq., of Blackheath, Kent, was celebrated in London on the 24th ult. We learn that Captain de Khotinsky and his bride sailed, per ss. *Teutonic*, for a tour in the United States, where he intends to establish a lamp factory at Boston for the manufacture of the Khotinsky lamp and other appliances used in connection with his system.

The New West India Cables.—The new cable laid by the *Westmeath* for the Société Française du Télégraphes Sousmarin's between Fort de France, Martinique, and Paramaribo, Dutch Guiana, was opened on the 9th December for international traffic. The provisional tariff established by the Société Française des Télégraphes Sousmarins is an addition of 2.20 francs per word to the existing rates to Martinique. The Anglo-American Company notifies that in consequence of certain misunderstandings which have arisen with respect to telegrams sent by post from Mole-St. Nicolas to Port-au-Prince, and from Colon to Barranquilla, it is necessary to remind the public that these telegrams carry, in addition to the tariff, a postal tax of 1.25 francs.

University College, Aberystwyth.—The workshop accommodation of the physical laboratory in the University College of Wales, Aberstwyth, has recently been considerably extended, and arrangements are being made for a course of instruction in electrical engineering. The recent additions include a high speed gas engine, specially adapted for electric lighting, a Crompton dynamo (shunt and compound wound), and a Crompton D.D. arc lamp, &c.

Extension of Telephony in South Wales.—The South Wales Telephone Company have opened communication with Port Talbot.

Improving Insulation.—Perhaps some of our readers may know whether the electrolytic method of improving insulation, described in our correspondence columns by Mr. A. A. Campbell Swinton, has ever been previously adopted.

American Company Dividends.—The New York Edison Electric Illuminating Company has declared a quarterly dividend of 1 per cent., payable January 15th, with an extra 5 per cent. in scrip, convertible upon an increase in the capital stock, and bearing the same interest as the present stock; Bell Telephone, 3 per cent., all payable January 15th.

Electric Lighting at Bognor.—At a meeting of the Local Board, last week, a letter was read from the secretary of the Electric Trust, Limited, stating that the company were prepared to enter into negotiations with a view to undertaking the public lighting of Bognor by electricity. They would be prepared to supply a 16-C.P. lamp for £4 per annum, and enter into a three years' agreement. The system would be similar to that adopted at Woking, and the company invite the board to visit the works at that place, when their system of working would be fully explained. The matter was eventually referred to a special committee.

Electric Lighting Fatality.—Yet another victim is added to the long list of fatal accidents due to electric lighting currents. At Chicago, on the 2nd December, a linesman was instantaneously killed from coming in contact with an electric light wire. Details of the mishap are not yet to hand. So long as bare wires are employed, or indifferent insulation made use of, undertakers may rely on electric lighting for some addition to their business.

Cable Subsidy.—In a paper read before the Royal Colonial Institute on November 11th, Mr. George S. Mackenzie stated that the German Government had granted to the Eastern and South African Telegraph Company an annual subsidy of £5,000 for the cable which this company has just laid between the Island of Zanzibar and Bagamoyo, the capital of the German Protectorate on the East African Coast.

Good News for Wine Bibbers.—A new cure for gout has, according to the *Matin* of Paris, been discovered by Mr. Edison, the American electrician. It is stated to consist in the simultaneous use of lithine and electricity.

City and South London Railway.—It is rumoured that this railway will be opened on Monday for public traffic.

NEW COMPANIES REGISTERED.

Marine and General Automatic Company, Limited.—Capital £20,040 divided into 4,000 ordinary shares of £5 each and 40 founders' shares of £1 each. Objects: To purchase from W. T. Wright Thackeray, Isaac Hurn and John Davies, the patent rights of improvements in automatic electrical tell-tale apparatus, with power to purchase other inventions relating to marine and other engines. Signatories (with one ordinary share each): J. Davies, East Sheen; G. J. Bridges, Chepstow Rise, Croydon; S. Bradford, Kingston-on-Thames; Isaac Carr, Walthamstow; T. E. Colcute, 5, Lancaster Place, Strand; *Lieut. St. John, R.N., 119, Confield Gardens, West Hampstead; H. C. Bridges, 20, Hart Street, W.C. The first directors are Lieut.-Colonel F. Despard, Anthony McKeand, Lieut. St. John, and Thomas Wilkins, C.E. Remuneration—chairman £3 3s., and each director £2 2s., for every meeting attended. Registered 29th ult. by Andrew Wood & Co., 8, Gt. James Street.

Plenty & Son, Limited.—Capital £25,000 in £10 shares. Objects: To take over the business of marine, general and mechanical engineers, carried on by Plenty & Son, at the Eagle Iron Works, Newbury, Berks. To carry on the business of electricians and as manufacturers and dealers in apparatus and things required for the generation, distribution, supply, accumulation and employment of electricity. Signatories (with one share each): *E. P. Plenty; E. P. Plenty, Jun.; John Mason, Newbury, Berks; Laurence Read, 18, Hanover Street, W.; J. Clarke, Chieveley, Berks; *Earl Russell (electrical engineer), Amberley Cottage, Maidenhead; *H. Wethered, Clifton, Bristol. The signatories denoted by an asterisk are the first directors. Qualification 50 shares; the company in general meeting will appoint remuneration. Registered 29th ult. by R. Jordan, 120, Chancery Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

"Electrician" Printing and Publishing Company, Limited.—The annual return of this company, made up to the 28th October, was filed on the 3rd inst. The nominal capital is £10,000 in £10 shares; 940 shares are taken up, 800 of which are considered as fully paid. Upon 140 shares the full amount has been called and paid.

Woodhouse and Rawson Electric Construction and Maintenance Company (Lancashire, Yorkshire and Cheshire), Limited.—The final winding up meeting of this company was held on the 25th ult., when an account was given, showing the manner in which the winding up has been conducted and the property of the company disposed of. The notice was filed on the 4th inst.

Electric Tramways, Construction and Maintenance Company, Limited.—The annual return of this company, made up to the 2nd July, was filed on the 3rd inst. The nominal capital is £250,000 in £1 shares, but although the company has been in existence since the 8th December, 1886, only seven shares have been taken up, and upon these no call has been made or paid.

Electric Wiring and Fittings Company, Limited.—An agreement of 24th ult., filed on the 5th inst., between Latimer Clark, Muirhead & Co., Limited, and this company, provides for the cancellation of 1,500 fully paid shares allotted to the former under an agreement of 22nd November, 1889.

Atlas Engine Company, Limited (engineers, contractors and electricians).—The statutory return of this company is made up to the 2nd September. The nominal capital is £12,000, in £1 shares, but only seven are at present taken up, and upon these the full amount has been called and paid. Registered office, Poole, Dorset.

Gordon Electric Traction Syndicate, Limited.—An agreement of 18th August between John Gordon, of 13, Nettleton Road, New Cross, electrical engineer, provides for the purchase from him by the company of a system of electric street car traction, provisionally protected on the 5th May, No. 6,083. The purchase consideration is £600 in fully paid £10 shares. Mr. Gordon is appointed managing director for two years, at a salary of £4 per week.

Sheffield Telephone Exchange and Electric Light Company, Limited.—An agreement of 9th September (filed 6th October) provides for the taking over, by this company, of the business carried on there by the company in liquidation of the same title. The new company will discharge the debts and liabilities of the old company, and shall adopt and perform all its contracts and engagements now binding. Every shareholder other than Mr. John Tasker will be entitled to one new share, credited with £8 as paid up in respect of each £10 share in the old company, and the said Mr. J. Tasker, in respect of each of 3,077 shares, with £8 paid up, shall have allotted to him, or his nominees, one share in the new company, credited with £8 paid up; and he undertakes to make no claim in respect of 2,000 fully paid shares held by him.

Plymouth and District Pulsion Telephone.—The statutory return of this company, made up to the 25th ult., was filed 29th ult. The nominal capital is £4,600, in £1 shares. 4,150 shares are taken up, upon 3,100 of which 1s. per share has been called, and upon £1,050, 3s. per share. The calls paid amount to £3,257 10s.

Woking Electric Supply Company, Limited.—The annual return of this company, made up to the 19th ult., was filed 24th ult. The nominal capital is £20,000 in £5 shares. 2,067 shares are taken up, 2,000 of which are considered fully paid. Upon 60 shares 5s. per share has been called, and upon seven shares £1 5s. has been called, the calls paid amounting to £23 15s.

Nonpariel Electric Syndicate, Limited.—An agreement of 21st ult. (filed 27th ult.) with J. Tarbottom Armstrong, of 8, Suffolk Lane, and J. Mason, of 28, Cardigan Road, Bow (the vendors), provides for the purchase by the company of the letters patent No. 1,757, dated 12th October, 1880, relating to an improved automatic coin-freed apparatus for imparting electric shocks, together with the machines and appliances belonging to the vendors. The consideration is £4,000, half in cash and half in fully-paid shares.

CITY NOTES, REPORTS, MEETINGS, &c.

Fowler-Waring Cables.—Meetings of electrical companies have been prolific during the past few days. Fowler-Waring Cables shareholders dropped in to their annual meeting to ascertain the date of probable dividends. The chairman met them with statements of delays (not specified), which were now overcome. A good factory had been secured, an able manager was running it, and the directors expected that from that day there would be nothing but plain sailing. It is a remarkable fact that the position of a company looks brighter and sounder on the day of the annual meeting than at any other subsequent or previous period. Shareholders were invited to view samples of work at the London office, and the machinery at the works. If this were done, it was said, they would recognise the sound basis on which the company rested. It is to be hoped, and we believe, that there is a sounder foundation than samples and machines. In the course of the meeting it was remarked that the board of directors, which is certainly a large one, ought to be reduced. It is said that one member, Colonel North, is so impressed with the capabilities of his colleagues that he has not deemed it necessary to put in an appearance at any single board meeting this year.

The Electric Construction Corporation.—This corporation held its first annual meeting on Monday. The chairman (Sir H. Mance) remarked that the company possessed patents of undoubted value, which, although undeveloped, would, in the hands of subsidiary companies, now formed, prove a solid source of income. Upon paper their transactions looked very flourishing indeed, but he hoped shareholders would support the policy of the directorate in the decision not to apply any profits of the sales of patents to the credit account until the patents had been written off. They were carrying on, at Wolverhampton and Millwall, continuous experiments. A notable one was the extraction of phosphorus by means of electricity. In view of the progress of electric lighting in England, and probable contracts, was decided, in order to secure increased business, to make an issue of £100,000 of debentures bearing six per cent.

Reuter's Telegram Company as an Advertising Concern.—Reuter's Telegram Company is taking advantage of that clause of articles of association which enables any commercial undertaking to make money out of business, as widely different as the supply of public electric lighting and the washing of private linen. It is intended to take up an international advertising agency by means of their cables.

The National Telephone Company; another Magna Charta.—The National Telephone Company will pay, in a few days, a dividend of 5 per cent., which is the last before the expiry of the patents held by it and its predecessor with peculiar injudiciousness for a good many years. During this period, their bearing towards customers has slowly, if silently, created a host of enemies, whose ill feeling and bitterness may have great influence on future developments of this concern. The company's position is analogous to that of King John, and the charter of liberty for the users of the telephone may be said to date from July of 1891.

The Gülcher (New) Electric Light and Power Company, Limited.—The report of this company and balance-sheet to June 30th, 1890—nearly six months after date—are to hand. An important feature mentioned in the report is that the 10 per cent. debentures, of which class only £400 at present remains unredeemed, has been paid off. We notice that a detailed profit and loss account will be submitted to the shareholders at the general meeting. As the balance from this account (£201 17s. 7d.) is given in the balance-sheet, it is difficult to see why so long a period should elapse before the detailed statement is ready. The directors state that the heavy interest payable on the second mortgage debentures has alone prevented the payment of a dividend, and now that these are practically cleared off, we hope that this year's account will prove even much more satisfactory than the last.

The Fowler-Waring Cables Company, Limited.

THE first annual report of the Fowler-Waring Cables Company was presented to the shareholders on Friday last. At the time of the statutory meeting they hoped that the buildings and machinery would be completed in spring or early summer, but there were so many unexpected delays, that only within a recent period has it been possible to execute orders at North Woolwich. The directors regret that in consequence of these delays they are unable to present a favourable balance-sheet, but they are glad to be able to state that the work is now proceeding well, and they look forward with confidence to the future.

A transfer of the work from Leeds has been effected, and a portion of the plant has been taken over, in accordance with the agreements made with Messrs. John Fowler and Company (Leeds), Limited.

The following is the general manager's report:—Since assuming the management of the company in the beginning of July, I have been mainly occupied with the organisation and equipment of the factory, which is now on a thoroughly good working basis. Many of the machines, which are of a particularly light construction, were, unfortunately, damaged in transport from America, and the repairs and renewals have been somewhat tedious, and have necessarily involved considerable delay. They are now, however, in operation, they are highly efficient machines, and it is doubtful if their working capacity is rivalled in this country.

In the selection of suitable foremen for the various departments, I have been specially fortunate in securing the services of a number of men of long experience in cable manufacture, and the quality of the work now produced is most favourably commented upon by all who have used or seen our cables. Although the orders completed up to date do not represent a very large sum, they are still significant as opening business in all the important branches of electrical engineering, and in no case is there a failure recorded against our company.

In telephony, we have manufactured a number of important cables for the National Company, and one composed of 50 wires is now being laid in the tunnels of the Metropolitan Railway. In cost and efficiency, I believe we can easily distance all our rivals in telephone cables, and there must be an immense development in the immediate future of underground telephone systems.

In telegraphy, we have had opening orders from several of the leading railway companies, and our prospects with the Post Office Telegraph Department are exceedingly good. We have also fulfilled trial orders for several of the Colonial Telegraph Departments, and our reports from them foreshadow future business.

The branch of electrical engineering which is at present commanding most attention is the transmission of power, and it is satisfactory that only our cables are employed in the new City and South London Subway, which is the first electric railway in this country.

In electric lighting, we have a constantly-increasing business, but it is here we meet with the keenest competition. The use of lead-covered cables will greatly extend when their value becomes more widely known. Rubber covered wires, however, are often specified to the exclusion of all others, and we think it advisable to meet the large demand for these conductors, and my arrangements for the manufacture of these are almost complete. It is our intention to manufacture all classes of electrical conductors, and we are also prepared to contract for carrying out electrical operations of every description.

Every year marks a steady advance in the progress of the electrical industries, and I am confident that we shall have an important share in the developments of the future. Our factory is splendidly situated, and admirably adapted to our requirements.

At the meeting the Chairman (Mr. W. Fowler) said that when he had met the shareholders a year ago he had certainly anticipated that they would make further progress during that period than had proved to be the case; but they had met with unexpected delay, and were consequently not so forward has they had hoped to be. He was glad to tell them, however, that they had now a factory in most excellent order, and would be able to do a large and profitable business in future. They had, too, and had had for some months past, a most excellent manager, who resided in the factory, and was consequently able to exercise a continued supervision. He would like any shareholder who felt any doubt about the company to go down and look over the factory; he thought he would agree that the position was a good one, the machinery excellent, and the work of the most superior quality. As to the quality of the work, an inspection of the samples to be seen at their offices in Queen Street would satisfy anyone that it was of the most excellent character. With regard to the condition of the company's business, the report—combining as it did both the managers' and directors'—stated that so clearly, that it was needless for him to add to it. He would say, however, that as the directors had made no profits for the shareholders (perhaps they ought not to have expected any the first year) they had taken no fees, although they had done a great deal of hard work, and had had a great deal to think about.

The report was seconded and carried *nem. con.*

On the motion to re-appoint the auditors, a shareholder objected to the amount of fees (50 guineas per annum) which they received, and it was finally resolved that though they should be re-appointed, that the directors should confer with them and endeavour to obtain a reduction.

The same shareholder thought that seven directors were too many for so small a company. It would be most invidious for him to single out any individual, but he hoped that the board would themselves consider this matter, and that when next the company was assembled there would be a smaller directorate.

The usual vote of thanks concluded the meeting.

The Electric Construction Corporation.

THE first ordinary general meeting of this corporation was held at Worcester House last Monday.

The Secretary read the notice convening the meeting, and also the auditors' report.

The Chairman (Sir Henry C. Mance), in going through the accounts, said that the £4,061 on account of apportionment of profit between the vendor and the corporation, which appeared on the credit side of the profit and loss account, represented the amount which, after liberal deductions for depreciation, cost of experiments, &c., the auditors certified as profits belonging to capital, and that, although they had taken over the benefit of the work of the company from September, 1888, they were not allowed to account as revenue any profits made before the date of the incorporation of the company, but they would understand that though they had not these earnings set out as profits, they had them in the increased value of the business. The items works, sales, and expenses spoke for themselves, and he had only one remark to offer—that, in working out the rate of profit, they should deduct a considerable part of the £14,000 charged as head office expenses, for these expenses covered a period of nearly 16 months—not merely 12. In connection with the interest upon temporary loans, it had been necessary to obtain temporary advances from their bankers in order to complete the agreement with the vendors. Part of it might have been charged to capital, but the directors had thought the placing of the affairs of the company upon a sound financial basis was of more importance than the presenting a more favourable balance-sheet. Speaking of the expenses they had been put to for advertising, the chairman said they would easily understand that advertising must always be a serious cost. Considerable expense, too, had been incurred for goods sent to the Edinburgh Exhibition, which was practically another form of advertising, and in pursuance of a policy of being always on the safe side, and of remembering that returned goods were often much depreciated in value, they had written the expense entirely off their books, so that if anything came into the funds from it it would be all profit. When the corporation had taken over the business there had been foreign patents of undoubted but of undeveloped value. The patent fees themselves were a heavy charge, whilst the income was nominal. The directors had realised these foreign patents by handing them over to subsidiary companies and accepting payment in shares. Experiments were constantly being made at their works at Wolverhampton and Millwall, and the chairman anticipated that before very long they would be possessed of a means of obtaining phosphorus by means of electricity. It might be in the minds of some of the shareholders that the aluminium process had been entirely revolutionised by the application of electricity, and he saw no reason why it should not be so with phosphorus. Turning to the balance sheet, he regretted that calls in arrear should form so large an item, but they had been passing through a very difficult and trying time in the City, and many gentlemen had had great difficulty in meeting the calls made upon them. Liabilities to trade accounts included a substantial sum in reserve, which they were not likely to be called upon to use, and the liabilities to capital account were almost paid off, though there were still considerable liabilities for the Bushbury works, and other matters, in course of settlement. Their contract for the equipment of Rathbone Place and Manchester Square stations was now almost complete, though there was a responsibility for the running of the machinery which would not disappear for some time to come. With regard to contingent liabilities for calls made by the subsidiary companies, there was not much likelihood of their becoming actual liabilities, except in case of such a development of the business of these subsidiary companies as would be a matter of congratulation to themselves. Turning to the credit side, the purchase money, £397,300, had been reduced by stock, book debts, &c. This was merely a matter of book-keeping, for the items appeared lower down; but the further reduction of £100,000 for licenses and sales was not a matter of book-keeping, a fact on which they might congratulate themselves. Their capital expenditure since the acquisition of the business had been practically limited to the laying out of the new Bushbury works, the cost of which had been greater than was originally contemplated; but they had felt themselves bound to be liberal in this direction for the sake of the increased facility in turning out work, for while they warmly desired to make profits out of the subsidiary companies, they must look for future dividends to their manufacturing profits, and their business was to put their company into the foremost rank, as they had endeavoured to do. While on this subject, it was not enough to have a reputation for turning out good work—that they had—they must have a reputation for turning it out with despatch. During the past year they had been obliged to refuse orders because they could not guarantee delivery within the time appointed; but now they had a factory at their disposal, which would enable them to meet all the requirements likely to be made in the future, as the shareholders would agree if they would go down and see it for themselves. Looking at the numerous applications made all over the country for provisional orders, and the progress already made by the different supply companies, they could have no doubt for the future of the electric light; but great as was this field, he thought it likely to be eclipsed by the demand made for electricity for other purposes. In America, the motor industry was greater than the lighting industry. In this matter they were not only better, they were cheaper than any of their rivals. If any of the shareholders should visit their works at Bushbury they would find how thoroughly the directors believed in the future transmission of power by electricity for all the machinery there was worked by power communicated electrically. They had been disappointed in the matter of train lighting, and gentlemen who owned shares in railways were urged to bring pressure to bear upon their directors, but they had been more fortunate with electric traction, for a series of electric tramcars had been established at Birmingham, where they were now working in a very satisfactory manner, and this he hoped was only the first of a long series of installations to be made all over the country. Seeing these installations coming, and having regard to the necessary expenditure on new works, he thought the time had now come to ask for more capital. They proposed to issue the sum of £150,000, in 6 per cent. debentures. They had postponed this as long as possible, but they thought now they would be neglecting the interests of their shareholders if they did not make the issue at the very latest early next year. They hoped these debentures would be mainly taken up by the shareholders, while as for the directors they were quite willing to take up more than their share. There would, however, be a public issue in order to get a quotation on the Stock Exchange.

Some shareholders having spoken criticising the action of the directors in selling so large a part of their business to subsidiary companies, as turning into a company promoting what should be a manufacturing concern, and one of them having asked whether this had anything to do with the retirement of Sir Douglas Fox,

Mr. J. Spencer Balfour stated in reply that there was no reason whatever for the retirement of Sir Douglas Fox except the one he himself assigned, namely, that he had not time to attend to the affairs of the company. As to the policy of the board in selling their business to subsidiary companies, it was the wisest course to adopt, because it enabled them to give their attention to manufacturing, which would otherwise be neglected. As to the rate of interest—6 per cent.—which was proposed to be paid upon debentures, this was the usual rate, but the debentures could easily be issued at 5 per cent. if the shareholders in the corporation would take them at that rate.

The adoption of the report having been moved, seconded and carried, the question of the reappointment of the retiring directors came up for discussion. Sir Daniel Cooper, with Messrs. Balfour, Courtenay and Dibley were reappointed, and Mr. Mander proposed that Mr. Thomas Parker, the managing director of the company, take the place of Sir Douglas Fox, resigned. This was opposed by Sir Daniel Cooper and some shareholders on the ground that a seat at the board would be incompatible with his present position as servant of the corporation, and the motion was finally withdrawn.

The auditors were then re-elected, and a vote of thanks to the chairman and board concluded the meeting.

Reuter's Telegram Company, Limited.

ON Saturday last, at 12, a special general meeting of the company was held at their offices in Old Jewry. The secretary read the notice convening the meeting, and two resolutions, the first, that the company's capital be increased to £100,000; and the second, altering the provisions of the memorandum of association and giving the company power to carry on the business of advertisement contractors and agents.

The Chairman (Sir J. C. D. Hay) remarked that the two resolutions were interdependent upon one another, and that unless both were carried the other one would be inoperative. Proceeding, he said that: Before moving the adoption of the resolutions, he would explain the objects in view in asking an extension of the powers of the company and an increase of capital. They must not suppose that the present capital was insufficient for the existing business. True, they had to incur considerable expense in keeping abreast with the growing demands for telegraphic intelligence, but at present their capital was adequate, so far as it was necessary to provide agents and correspondents with funds; and though it might be found advisable in the interests of their subscribers to supplement existing services with special accounts of remarkable events, trials, fires, &c., on a larger scale than had been hitherto considered necessary, yet these would be the subject of further consideration in conjunction with the newspapers themselves, and would, no doubt, be met by the contributions which would recoup the outlay. The primary object of the proposed alteration in their memorandum of association, and the increase of their capital, was to enable them to undertake the business of collecting advertisements for the newspapers, who were their supporters. Their organisation was particularly adapted for this class of business, and the idea had been long entertained by their managing director, who had not failed to notice the great expansion of advertising of late years. The law had until recently regarded a memorandum of association as unalterable; but during last session an Act was passed empowering companies, under the sanction of the High Court, to enlarge the sphere of their operations, of which power they proposed to avail themselves. It was obvious that with agencies in all the capitals of the world who were brought into direct communication with the newspapers, that the company had exceptional means of establishing an international advertising business on a large scale, with immense advantage to their subscribers. Some apprehension had been expressed in certain quarters that the working of the advertisement business might

prove detrimental to the telegraphic services, inasmuch as the latter had to deal with financial affairs, and many things that advertisers might influence; but he would point to their reputation, and ask if it were likely that the directors would commit the suicidal folly of allowing any advertiser to influence the impartiality which had characterised their service since its creation. As a safeguard, however, it was proposed to keep the telegrams strictly apart from the advertising branch, which would be managed by a separate staff in separate offices. They were sanguine that the new business would be found a good source of revenue, but shareholders must not look for increased dividends at the commencement. The organisation of an international business took time, and could only be accomplished after much negotiation; but they had taken preliminary steps abroad in conjunction with the largest advertising agency on the continent, and as soon as the shareholders' consent was obtained, and the sanction of the High Court obtained, they would be ready to start the new machinery. In addition to advertisement business, they believed it might be found profitable to undertake telephonic and other services, and to extend their business in many directions, now barred by their restricted memorandum of association.

The Chairman then put the resolutions, which were seconded by Baron de Reuter, and carried *nem. con.* Another meeting will be held, in accordance with the Act, on the 23rd, to confirm them.

The Ward Electrical Car Company, Limited.

THE first annual general meeting of this company took place at the depôt, 12, Dacre Street, Westminster, on Wednesday, the 3rd December, 1890, Mr. E. R. Cummins in the chair.

The Chairman reported that the details of the contract for the construction of the first line of omnibuses, and for the charging station, had now been finally settled with the Electric Construction Corporation, Limited, and that the work will be at once proceeded with; also that the Board intended, as soon as this line is running, to form a sub-company for London, to take over the station and omnibuses, and to work a large line of vehicles; that the various authorities concerned view with great interest the pending introduction of electrical carriages on the streets of London; and that it is intended to form sub-companies for other places in the U.K. and abroad.

The Managing Director then reported having just received an order for an electrical van for trade purposes from a firm who intend to largely introduce them, and that an important tramway company had practically concluded to place a contract with this company.

The Gülcher (New) Electric Light and Power Company, Limited.

THE directors in their report state that they have pleasure in presenting to the shareholders the balance-sheet for the 12 months ending 30th June, 1890.

It will be observed that the preference capital of the company, which on the 30th June, 1889, consisted of 12,277 preference shares, having £12,241 1s. 4d. paid up, consisted on the 30th June, 1890, 50,000 preference shares, having £30,797 8s. paid up.

It will also be seen that the £10 per cent. 2nd debentures, which, on the 30th June, 1889, amounted to £8,862 10s., and which, at the date of the last report, had increased to £16,000, were on the 30th June, 1890, reduced to £400.

This satisfactory alteration of the capital account is mainly due to the response made by a limited number of shareholders to the prospectus issued on the 1st January last, inviting subscriptions for the then unissued preference shares.

The central stations for the public lighting of Wellington, New Zealand, upon which, on the 30th June, 1889, the company had expended £9,598 18s. 8d. were shortly afterwards completed. On the 30th June, 1890, this important installation stood as a debtor in the company's books for £13,486 13s. 3d., since which time the amount has not been increased.

The directors, in their last report, pointed out to the shareholders that the commercial success of this undertaking would depend entirely upon the provision of further capital for private lighting. They concluded, however, after careful consideration, not to lock up so large a portion of the newly-subscribed capital as would be necessary to enable the company exclusively to provide for this private lighting. A well-supported syndicate has accordingly been formed, which will not only provide for the private supply of the town but will ultimately take over this company's business in New Zealand, together with the benefit of the contract for public lighting, entered into between this company and the Mayor and Corporation of Wellington.

The particulars of the contract between the New Zealand Electrical Syndicate and this company, and of other contracts undertaken and carried out during the past year, will be supplied at the general meeting, when a detailed profit and loss account will also be submitted to the shareholders.

In the autumn of last year this company contributed towards the registration of "The South-Western District and Thames Valley Electricity Supply Company, Limited," from which the directors have reason to anticipate good results.

The gross manufacturing profits for the year ending 30th June, 1890, amounted to £3,097 2s. 4d., which, compared with the manufacturing loss of £1,417 6s. 6d. in the preceding year, must be regarded with satisfaction.

The heavy interest payable on the second mortgage debentures (nearly all of which, however, have been now paid off), has alone prevented the declaration of a dividend. Since the last general meeting Mr. Binswanger has resigned his seat at the board. The directors, under the powers conferred on them by the articles of association, recently elected Mr. C. S. B. Hilton, a large shareholder, to assist in the direction of the company. Mr. De Castro and Mr. Hilton retire from the board, but, being eligible, offer themselves for re-election.

Mr. Russell Day, the auditor appointed at the last general meeting, also retires, but offers himself for re-election.

THE BALANCE SHEET, JUNE 30TH, 1890.

Dr.	£	s.	d.	£	s.	d.
To capital, authorised	70,000	0	0			
Issued 20,000 Deferred shares of £1 each, fully paid ...	20,000	0	0			
„ 12,277 Preference Shares of £1 each, 20s called up	12,277	0	0			
„ 37,723 Preference Shares of £1 each, 7s. 6d. called up	14,146	2	6			
70,000	£26,423	2	6			
Less unpaid	2,942	5	0			
	£23,480	17	2			
Add calls paid in advance ...	7,316	10	10			
				30,797	8	0
To £6 per cent. First Mortgage Debentures				8,000	0	0
„ £10 per cent. Second Mortgage Debentures	£10,000	0	0			
Less paid off	9,600	0	0			
				400	0	0
„ Bills payable				393	16	7
„ Creditors as under:—						
Trade Debts	1,561	12	1			
Commissions	1,500	0	0			
Interest on Debentures ...	189	7	10			
Rent, Rates and Taxes ...	56	19	3			
Law Costs	190	8	4			
Salaries, &c.	132	5	1			
Directors' Fees	236	15	10			
				3,867	8	5
„ National Provincial Bank of England, Limited				2,493	7	3
				£45,952	0	3
„ Surplus at 30th June, 1889 ...	405	13	10			
„ Balance from Profit and Loss Account	201	17	7			
				203	16	3
				£46,155	16	6

Cr.	£	s.	d.	£	s.	d.
By Preliminary Expenses, Balance from June, 1889...	800	0	0			
Add Broker's Commission, &c.	1,600	0	0			
	£2,400	0	0			
Less written off	400	0	0			
				2,000	0	0
„ Plant (as valued)				7,082	18	6
„ Stock in England (as valued)...				17,766	1	6
„ Stock in New Zealand (at cost)				1,048	6	3
„ Installation at Wellington, N.Z. (at cost)				13,486	13	3
„ Trade Debtors				4,680	17	4
„ Bills receivable				69	3	9
„ Cash in hand				21	15	11
				£46,155	16	6

I have examined the above balance-sheet with the books and vouchers at the offices of the company, and I hereby certify the same to be correct.

RUSSELL DAY, *Auditor.*

December 6th, 1890.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending November 28th were £6,361; and for the week ending December 5th were £5,955.

The Great Northern Telegraph Company, Limited. The receipts for the month of November amounted to £25,600; 1st January—30th November, 1890, £326,400 as against £282,400 for the corresponding months of 1889, and £250,200 for the corresponding months of 1888.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (December 4.)	Closing Quotation. (December 11).	Business done during week ending December 11, 1890. Highest.	Lowest.
250,000£	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101		
1,381,380£	Anglo-American Telegraph, Limited	Stock	48½— 49¼	48½— 49⅝		
2,809,310£	Do. do. 6 p. c. Preferred	Stock	85 — 86	85½— 86½	86	85¼
2,809,310£	Do. do. Deferred	Stock	13¼— 14	13¼— 13⅝	13⅝	13¼
130,000	Brazilian Submarine Telegraph, Limited	10	11½— 11⅝	11½— 11⅝	11⅝	10⅝
84,500£	Do. do. 5 p. c. Bonds...	100	101 —103	101 —103		
75,000£	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	104 —108	104 —108		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1¼— 1⅝	1¼— 1⅝		
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1½— 2	1½— 2		
$7,216,000	Commercial Cable, Capital Stock	$100	102 —104	102 —104	104½	...
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	7/16— 9/16	7/16— 9/16		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5⅛— 5¼	5⅛— 5⅛		
16,000	Cuba Telegraph, Limited	10	11½— 12	11½— 12		
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18	17½	17
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼		
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
60,710	Direct United States Cable, Limited, 1877	20	10½— 10⅝	10½— 10⅝	10⅝	...
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	13⅜— 14	13⅜— 14⅛	14 1/16	13 13/16
70,000	Do. 6 p. c. Preference	10	14½— 15	14⅝— 15½	15½	14⅝
200,000£	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109	108½	
1,200,000£	Do. 4 p. c. Mortgage Debenture Stock	Stock	103 —106	104 —107	105⅞	105½
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	13¾— 14	13¾— 14⅛	14⅛	13 13/16
320,000£	Do. 6 p. c. Debentures, repay. February, 1891	100	101 —103	101 —103		
91,800£	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049 3,976 to 4,326	100	102 —105	102 —105		
325,200£	Do. do. Bearer Nos. 1,050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105		
145,300£	Eastern and South African Tel., Ld., 5 p. c. Mort. Deb., 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104	101 —104		
198,200£	Do. do. do. to bearer, Nos. 2,344 to 5,500	100	101 —104	101 —104		
201,600£	Do. do. 4 p.c. Mort. Debs. Nos. 1 to 2,016... ...	100	... ...	... ...		
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7⅞— 8⅛	7⅞— 8⅛	8 3/16	8 1/16
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000 ...	5	4¾— 5¼	4¾— 5¼		
70,000	Elmore's Patent Copper Depositing, Ltd., Nos. 1 to 70,000 ...	2	3½— 4	3¼— 4	3 13/16	...
67,385	Elmore's Wire Mfg., Ld., Nos. 1 to 67,385, issued at 1 pm. all pd.	2	1⅝— 2⅛	1⅝— 2⅛		
20,000	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£4 only paid)	5	2¼— 3½	2¼— 3½		
180,227	Globe Telegraph and Trust, Limited	10	8½— 9	8¾— 9	8 11/16	8¾
180,042	Do. do. 6 p. c. Preference	10	14½— 14¾	14½— 14¾	14¾	14 7/16
150,000	Great Northern Tel. Company of Copenhagen	10	15¾— 16¼	15¾— 16¼	16¼	16 1/16
15,000£	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	101 —104	101 —104		
230,000£	Do. do. do. (issue of 1883) ...	100	104 —107½	104 —107		
9,384£	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11½— 12½	11½— 12½		
5,334£	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11½— 12	11½— 12½		
41,800	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18 — 19	18½— 19½	19½	18½
200,000£	Do. do. 4½ p. c. Deb., 1896...	100	100 —102	100 —102	101½	...
17,000	Indo-European Telegraph, Limited...	25	35 — 37	35 — 37		
11,334	International Okonite, Ltd, Ordinary Nos. 22,667 to 34,000 (£10 p.)	10	9½— 10	9½— 10		
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9½— 10	9½— 10		
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7		
100,000£	Do. do. do. 6 p. c. Debentures ...	100	105 —109	106 —109		
43,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 £8 pd.	10	6¾— 7½	7 — 7½	7½	7
438,984	National Telephone, Limited, Nos. 1 to 438,984	5	4½— 4¾	4½— 4⅝	4⅝	4½
15,000	Do. 6 p. c. Cum. 1st Preference	10	12½— 12⅝	12⅝— 12¾	12 7/8	
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	9⅝— 10½	9⅝— 10½	10	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ¼	⅛— ¼		
9,000	Reuter's, Limited	8	8½— 9	8½— 9	8½	...
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3¼ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	108 —112	108 —112	109½	109
78,949	Swan United Electric Light, Limited ... (£3¼ only paid)	5	4½— 5	4½— 5	4⅝	4⅜
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45	44½	44½
150,000£	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
58,000	United River Plate Telephone, Limited	5	3 — 4	3 — 4		
146,128£	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 95	90 — 95		
3,200£	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8½— 9½	8½— 9½		
290,900£	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101		
30,000	West Coast of America Telegraph, Limited	10	3½— 4½	2 — 4	2½	...
150,000£	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	102 —107	101 —106		
64,174	Western and Brazilian Telegraph, Limited	15	10¾— 11¼	10¾— 11⅛	11	10⅞
27,573	Do. do. do. 5 p. c. Cum. Preferred	7½	6¼— 6⅝	6¼— 6⅝	6½	...
27,573	Do. do. do. 5 p. c. Deferred	7½	4½— 5	4½— 5	4⅝	...
200,000£	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000£	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3	2⅞— 3⅛	3	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¼— 11⅜	11¼— 11⅜	11⅜	...
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11 — 12	11 — 12		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	120 —125	120 —125		
175,100	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,953	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£3 only paid)	5	2¼ — 2⅜	2¼ - 2⅜		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6¼ paid), 7¼—7⅜.—Elmore Copper Depositing Priorities, 7 —7¼.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, £1 10s. paid, including premium, 2⅛—2¼.—House-to-House Company (£5 paid), 4¼—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 1⅞—2¼.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), 2⅛—2⅜.—Preference, 4⅛—4⅜.

BANK RATE OF DISCOUNT.—5 per cent. (4th December 1890).

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 682.*)

TIME CONSTANTS OF ELECTRO-MAGNETS.

I may here refer to some determinations made by M. Vaschy,* respecting the co-efficients of self-induction of the electromagnets of a number of pieces of telegraphic apparatus. Of these I must only quote one result, which is very significant; it relates to the electro-magnet of a Morse receiver of the pattern habitually used on the French telegraph lines.

	L, in quadrants.
Bobbins, separately, without iron cores	0·233 and 0·265
Bobbins, separately, with iron cores ...	1·65 and 1·71
Bobbins, with cores joined by yoke, coils in series	6·37
Bobbins, with armature resting on poles	10·68

It is interesting to note how the perfecting of the magnetic circuit increases the self-induction.

Thanks to the kindness of Mr. Preece, I have been furnished with some most valuable information about the coefficients of self-induction, and the resistance of the standard pattern of relays, and other instruments which are used in the British postal telegraph service, from which data one is able to say exactly what the time constants of those instruments will be on a given circuit, and how long in their case the current will take to rise to any given fraction of its final value. Here let me refer to a very capital paper by Mr. Preece in an old number of the "Journal of the Society of Telegraph Engineers," a paper "On Shunts," in which he treats this question, not as perfectly as it could now be treated with the fuller knowledge we have in 1890, about the coefficients of self-induction, but in a very useful and practical way. He showed most completely that the more perfect the magnetic circuit is—though, of course, you are getting more magnetism from your current—the more is that current retarded. Mr. Preece's mode of experiment was extremely simple; he observed the throw of the galvanometer, when the circuit which contained the battery and the electrmagnet was opened by a key which at the same moment connected the electro-magnet wires to the galvanometer. The throw of the galvanometer was assumed to represent the extra-current which flowed out. Fig. 56 represents a few of the

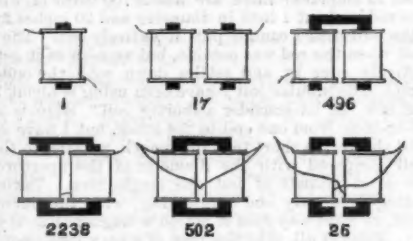

FIG. 56.—ELECTRO-MAGNETS OF RELAY, AND THEIR EFFECTS.

results of Mr. Preece's paper. Take from an ordinary relay a coil with its iron core, half the electro-magnet, so to speak, without any yoke or armature. Connect it up as described, and observe the throw given to the galvanometer. The amount of throw obtained from the single coil was taken as unity, and all others were compared with it. If you join up two such coils as they are usually joined, in series, but without any iron yoke across the cores, the throw was 17. Putting the iron yoke across the cores, to constitute a horseshoe form, 496 was the throw; that is to say, the tendency of this electro-magnet to retard the current was 496 times as great as that of the simple coil. But when an armature was put over the top the effect went up to 2,238. By the mere device of putting the coils in parallel, instead of in series, the 2,238 came down to 502, a little less than the quarter value which would have been expected. Lastly, when the armature and yoke were both of them split in the middle, as is done in fact in all the standard patterns of the British Postal Telegraph relays, the throw of the galvanometer was brought down from 502 to 26. Relays so constructed will work excessively rapidly. Mr. Preece states that with the old pattern of relay having so much self-induction as to give a galvanometer throw of 1,688, the speed of signalling was only from 50 to 60 words per minute; whereas, with the standard relays constructed on the new plan, the speed of signalling is from 400 to 450 words per minute. It is a very interesting a very interesting and beautiful result to arrive at from the experimental study of these magnetic circuits.

* Cantor Lecture. Delivered before the Society of Arts, February 3rd, 1890.

* "Bulletin de la Société Internationale des Electriciens," 1886.

SHORT CORES *versus* LONG CORES.

In considering the forms that are best for rapid action, it ought te be mentioned that the effects of hysteresis in retarding changes in the magnetisation of iron cores are much more noticeable in the case of nearly-closed magnetic circuits than in short pieces. Electro-magnets with iron armatures in contact across their poles will retain, after the current has been cut off, a very large part of their magnetism, even if the cores be of the softest of iron. But so soon as the armature is wrenched off the magnetism disappears. An air-gap in a magnetic circuit always tends to hasten demagnetising. A magnetic circuit composed of a long air-path and a short iron-path demagnetises itself much more rapidly than one composed of a short air-path and a long iron-path. In long pieces of iron the mutual action of the various parts tends to keep in them any magnetisation that they may possess; hence they are less readily demagnetised. In short pieces, where these mutual actions are feeble or almost absent, the magnetisation is less stable, and disappears almost instantly on the cessation of the magnetising force. Short bits and small spheres of iron have no "magnetic memory." Hence the cause of the commonly received opinion amongst telegraph engineers that for rapid work electro-magnets must have short cores. As we have seen, the only reason for employing long cores is to afford the requisite length for winding the wire which is necessary for carrying the needful circulation of current to force the magnetism across the air-gaps. If, for the sake of rapidity of action, length has to be sacrificed, then the coils must be heaped up more thickly on the short cores. The electro-magnets in American patterns of telegraphic apparatus usually have shorter cores, and a relatively greater thickness of winding upon them, than those of European patterns.

LECTURE IV.—DELIVERED FEBRUARY 10TH, 1890.

ELECTRO-MAGNETIC MECHANISM.

THE task before me to-night comprises the following matters:—First, to speak of that particular variety of the electro-magnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalising the pull of electro-magnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electro-magnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electro-magnet.

THE COIL-AND-PLUNGER.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the *coil-and-plunger*. Now, from quite early times, from 1822 at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil-and-plunger was even patented in this country in 1846 under the name of "a new electro-magnet." Electro-magnetic engines, or motors, were made on this plan by Page, and afterwards by others, and it became generally known as a distinct device. But even now, if you inquire into the literature of the text-books to know what are the peculiar properties of the coil-and-plunger arrangement, you will find that the books give you next to no information. They are content to deal with the thing in very general terms by saying: here is a sort of sucking magnet; the core is attracted in. Some books go so far as to tell you that the pull is greatest when the core is about half way in, a statement which is true in one particular case, but false in a great many others. Another book tells you that the pull is greatest at a point one centimetre below the centre of the coil, for plungers of all different lengths—which is quite untrue. Another book tells you that a wide coil pulls less powerfully than a narrow one, a statement which is true for some cases and not for others. The books also give you some approximate rules, which, however, are very little to the point. The reason why this ought to receive much careful consideration is because in this mechanism of coil-and-plunger we have a real means not only of equalising, but also of vastly extending the range of the pull of the electro-magnet. Let us take a very simple example for the sake of contrasting the range of action of the ordinary electro-magnet with the range of action of the coil-and-plunger.

Here are some numbers which are given in a paper with which I have long been familiar, a paper read by the late Mr. Robert Hunt in 1856 before the Institution of Civil Engineers, and discussed, with that eminent engineer, Robert Stephenson, in the chair. Mr. Hunt described the various types of motors, and spoke of this question of the range of action. He recounted some experiments of his own in which the following was the range of action. There was a horse-shoe electro-magnet which at a distance zero—that is, when its armature was in contact—pulled with a pull of 220 lbs.; when the distance was made only $\frac{4}{1000}$th of an inch (4 mils), the pull fell to 90; and when the distance was increased to 20 mils ($\frac{1}{50}$th of an inch), the pull fell to only 36 lbs. The difference from 220 to 36 was within a range of $\frac{1}{50}$th of an inch. He contrasts this with the results given by another mechanism, not quite the simple coil

and plunger, but a variety of electro-magnet brought out about the year 1845 by a Dane living in Liverpool named Hjörth, wherein a sort of hollow truncated cone of iron (fig. 57), with coils wound upon it—a hollow electro-magnet, in fact—was caused to act on another electro-magnet, one being caused to plunge into the other. Now we have no information what the pull was at

FIG. 57.—HJÖRTH'S ELECTRO-MAGNETIC MECHANISM.

distance zero with this curious arrangement of Hjörth's, but at a distance of 1 inch the pull (with a very much larger apparatus than Hunt's) was 160 lbs., the pull at 3 inches was 88 lbs., at 5 inches 72 lbs. Here, then, we have a range of action going not over $\frac{1}{10}$th of an inch, but over 5 inches, and falling not from 220 to 36, but from 160 to 72, obviously a much more equable kind of range. At the Institution of Civil Engineers on that occasion, a number of the most celebrated men, Joule, Cowper, Sir William Thomson, Mr. Justice Grove, and Professor Tyndall discussed these matters—discussed them up and down—from the point of view of range of action, and from the point of view of the fact that there was no means of working them at that time except by the consumption of zinc in a primary battery; and they all came to the conclusion that electric motors would never pay. Robert Stephenson summed up the debate at the end in the following words:—"In closing the discussion," he remarked, "there could be no doubt from what had been said that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question commercially speaking. Without, however, considering the subject in that point of view, the mechanical applications seemed to involve almost insuperable difficulties. The power exhibited by electro-magnetism, though very great, extended through so small a space as to be practically useless. *A powerful magnet might be compared, for the sake of illustration, to a steam engine with an enormous piston, but with an exceedingly short stroke; such an arrangement was well known to be very undesirable.*"

Well, from the discussion in 1856—when this question of the length of range was so distinctly set forth—down to the present, there have been a large number of attempts to ascertain exactly how to design a long range electro-magnet, and those who have succeeded have, as a general rule, not been the theorists; rather they have been men compelled by force of circumstances to arrive at their result by some kind of—shall we call it—"designing eye," by having a sort of intuitive perception of what was wanted, and going about it in some rough and ready way of their own. Indeed, I am afraid had they tried to get much light from calculations based on orthodox notions respecting the surface distribution of magnetism, and all that kind of thing, they would not have been much helped. There is our old friend, the law of inverse squares, which would of course turn up the first thing, and they would be told that it would be impossible to have a magnet that pulled equally through any range, because the pull was certain to vary inversely according to the square of the distance. I notice that, in a report of my second lecture in one of the London journals, I am announced to have said that the law of inverse squares did not apply to electric forces. I beg to remark that I have said no such thing. It is well to be precise as to what one does say. There has been a lively discussion going on quite lately whether sound varies as the square of the distance—or rather, whether the intensity of it does—and the people who dispute on both sides of the case do not seem to know what the law of inverse squares means. I have also seen the statement made last week in the columns of the *Times* by one who is supposed to be an eminent authority on eyesight, that the intensity of the colour of a scarlet geranium varies inversely with the square of the distance from which you see it. More utter nonsense was never written. The fact is, the law of inverse squares, which is a perfectly true mathematical law, is true not only for electricity but for light, for sound, and for everything else, provided it is applied to the one case to which a law of inverse squares is applicable. That law is a law expressing the way in which action at a distance falls off when the thing from which the action is proceeding is so small compared with the distance in question that it may be regarded as *a point*. The law of inverse squares is the law universal of action proceeding from a point. The music of an orchestra at 10 feet distance is not four times as loud as at 20 feet distance; for the size of an orchestra cannot be regarded as a mere point in comparison with these distances. If you can conceive of an object giving out a sound, and the object being so small in relation to the distance at which you are away from it, that it is a point, the law of inverse squares is all right for that, not for the intensity of your hearing, but for the intensity of that to which your sensation is directed. In no case, however, are sensations absolutely proportional to their causes. When the magnetic action proceeds from something so small that it may be regarded as a point compared with the distance, then the law of inverse squares is necessarily and mathematically true.

You may remember that I produced an apparatus (fig. 27) which I said was the only apparatus hitherto devised which did directly prove experimentally the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

The law of inverse squares is true; but it is not what one works with when one deals with electro-magnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetised, so far away from an electro-magnet (or rather from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them, that each of them may be regarded by comparison as a point, then the law of inverse squares may be rightly applied, but not unless.

Now we want to arrive at a true law. We want to know exactly what the law of action of the coil and plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas. We must begin with a simple case, that of a short coil consisting of but one turn acting on a single point pole. From this we may proceed to consider the effect on a point pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and, last of all, from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron, it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 ampères; there are about 700 turns of wire on the coil. The rod is about 1 inch in diameter and 20 inches long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in, and settles down with the ends equally protruding. The tubular coil I have been using is about 14 inches long; but now let us consider a shorter coil. Here is one here only half-an-inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a magnet that is placed on the axis? First of all, take the case of a very long, permanently magnetised steel magnet, so long, indeed, that any action on the

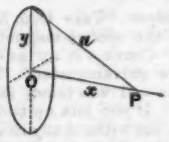

FIG. 58.—ACTION OF SINGLE COIL ON POINT-POLE ON AXIS.

more distant pole is so feeble that it may be disregarded altogether, and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in fig. 58 represent the centre of the ring, its radius being y. The line, O P, is the axis of the ring, and the distance from O to P we will call x. The slant distance from P to the ring we call a. Then the pull on the axis towards the centre of this coil varies inversely as the cube of a. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to fig. 59, which represents a section or edge view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 ampères, circulating once around a ring of 1 centimetre radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central point is 6·28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the

radius it has fallen to 2·22 dynes. At a distance equal to twice the radius, or one diameter, it is only 0·56 dynes, less than one-tenth of what it was at the centre. At 2 diameters it has fallen

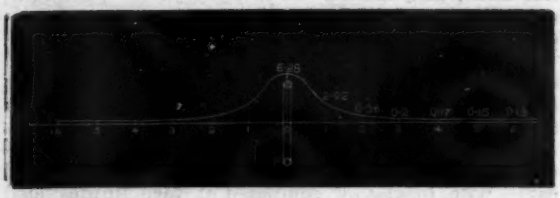

FIG. 59.—ACTION ALONG AXIS OF SINGLE COIL.

to 0·17 dyne, or less than 3 per cent.; and the force at 3 diameters is only about 2 per cent. of that at the centre.

(To be continued.)

NEW PATENTS—1890.

18491. "Improvements in dynamo-electric machines." R. KENNEDY. Dated November 17. *(Complete.)*

18537. "Improved method of signalling on railways, and appliances connected for electrically operating same." E. S. COOK. Dated November 17.

18554. "Improvements relating to the fixing in insulating bases of blocks for connecting electrical conductors." H. J. PIERCE. Dated November 17.

18555. "Improvements in electrical switches." H. J. PIERCE. Dated November 17.

18556. "Improvements in electrical switches." H. J. PIERCE. Dated November 17.

18557. "Improvements in electrical switches." H. J. PIERCE. Dated November 17.

18558. "Improvements relating to electrical pendants and other portable or movable electrical devices." H. J. PIERCE. Dated November 17.

18576. "Improvements in apparatus for controlling electric currents." R. H. C. NEVILLE. Dated November 18. *(Complete.)*

18587. "Improved form of electric locomotive." J. PLATT. (Communicated by F. W. DEAN, United States.) Dated November 18.

18589. "Improvements in electric railway signals." W. H. WADDELL. Dated November 18. *(Complete.)*

18625. "Improvements in and relating to apparatus for use in electric welding, forging, and other metal-working operations." H. H. LAKE. (Communicated by H. Lemp, United States.) Dated November 18. *(Complete.)*

18631. "Improvements relating to the welding of metals by electricity." H. H. LAKE. (Communicated by E. Thomson, United States.) Dated November 18. *(Complete.)*

18638. "Improvements in electricity meters." E. HARTMANN and W. BRAUN. Dated November 18. *(Complete.)*

18660. "An improved terminal for electric lampholders." A. J. MCGEOCH. Dated November 18.

18776. "Electric telegraphic communication between termini, intermediate stations, &c., and railway trams or vehicles in motion." A. T. J. CUTMORE, and F. H. BOINTON. Dated November 20.

18890. "Improvements in automatic telephone connectors." J. Y. JOHNSON. (Communicated by the Automatic Electric Exchange Company, United States.) Dated November 21.

18896. "Improvements in the process and apparatus for manufacturing copper tubes, sheets, strips, and wires by electrolysis." A. S. ELMORE. Dated November 21. *(Complete.)*

18904. "Improvements in magneto-electric telephonic apparatus." H. T. O. FRASER. Dated November 21.

18910. "Improved apparatus for stopping machinery by electricity." C. F. JOSZ. Dated November 21.

18913. "An improved electrical switch." E. L. JOSEPH. Dated November 21.

18969. "An improved apparatus for measuring the resistance and insulation of electric conductors." W. A. PRICE and W. E. GRAY. Dated November 22.

18993. "Improvements in and relating to electric clocks." N. PROKHOROFF and N. FAHLBERG. Dated November 22. *(Complete.)*

ABSTRACTS OF PUBLISHED SPECIFICATIONS 1889.

11941. "Improvements in switchboards for telephone exchange." MIX and GENEST and W. OESTERREICH, Germany. Dated July 27. 8d. Each switch-hole consists merely of two conducting portions, a socket and a spring, lying against and insulated from the former by means of ebonite or the like. 4 claims.

15963. "Improvements in the manufacture of electrodes or plates for electrical batteries." Dr. PAUL SCHOOP. Dated October 10. 6d. A compound soluble lead salt is decomposed by an electric current, its constituent parts being deposited upon suitably-shaped conducting plates or supports. Such a compound salt may be prepared by mixing sulpho-glycerine acid or naphthalin-sulpho acid, or both, with sulphuric acid, and adding thereto an oxide or carbonate of lead and one or more of the alkalies, potash, soda, or ammonia, until the acids are neutralised or saturated. 7 claims.

17521. "Improvements in the distribution and regulation of electric currents." W. CLARK. (A communication from abroad by S. Schuckert & Co., of Nürnberg.) Dated November 4. 11d. Consists:—1. In a system of distribution designed for a uniform tension of consumption and receiving electric energy from two or more current supply circuits (*a*) to regulate tensions at the terminals of all the supply leads with variable consumption of current, and (*b*) to allow of unequal falls of tension in the several supply leads with a maximum consumption of current. 2. At places where variation in the intensity of the light is required, to allow of the alteration of the tension of the lamps according to the brightness desired, both being effected without the usual resistances which consume uselessly a portion of the electrical energy, and convert the same into heat. 9 claims.

18821. "Improvements in electric baths, or apparatus for applying electricity for medical or other similar purposes." Dr. GUSTAV GARBTNER. Dated November 23. 8d. The inventor divides the bath into two perfectly separate compartments or cells by means of a partition made in two parts. The lower part of this partition is permanently united to the sides and to the bottom of the bath, but the upper part is capable of being removed, or of sliding upwards and downwards in guides, so as to be capable of joining the lower part, and forming with the latter a partition, making a tight joint with the sides and bottom of the bath. Both the upper and the lower divisions of this partition are cut away so as to form an opening between them, the edges of which are provided with India-rubber cushions or pads. Suitable electrodes or metal plates are provided around the interior of the bath at the sides, and those in one compartment are connected with the positive pole, and those in the other compartment with the negative pole of the electric generator or source of electricity. Inside these electrodes or plates a wood lining may be provided. 2 claims.

18939. "Improvements in and connected with railway and tramway vehicles and with their propulsion by means of electricity." H. P. HOLT. Dated November 26. 8d. According to these improvements the body of each vehicle is carried on two bogies, one at each end of the vehicle; but instead of the bogies being entirely below the under-framing, as in ordinary cases, it is arranged that the ends only of the vehicles shall rest upon and be carried by less than one-half of each bogie. 6 claims.

1890.

1037. "Improvements in mechanical telephones." R. C. M. BOWLES. Dated January 21. 6d. Consists in suspending or holding the telephone upon the line wire without other support than the wire itself, and then providing means for holding the diaphragm of the telephone under a tension equal to, or proportionate to, that line wire, and it further consists in providing means for adjusting the tension of the diaphragm. 4 claims.

2986. "Improvements in electric lamp sockets and devices attached thereto for regulating the light." W. F. WOLLIN and E. H. WERLINE. Dated February 25. 8d. The object of this invention is to provide means for controlling the intensity of the light of an incandescent electric lamp, so that it may be of any degree desired, as is the case with the flame of an ordinary gas burner. 7 claims.

3455. "Improvements in and relating to electric secondary batteries or accumulators." H. H. LAKE. (Communicated from abroad by T. Ewing, of New York.) Dated March 4. 8d. Relates first to a new construction of storage cell, and consists in the combination of the electrodes with the supporting bridge pieces of non-conducting material, with the interposed supporting and spacing bars of like material, and with the bolts or other means af clamping the various parts into a united body; and second, in a new method of preparing active material for use in storage cells, and preferably in cells of the form set forth. 8 claims.

3787. "Improvements in electric railways." H. W. LIBBEY. Dated March 10. 8d. Consists in the peculiar construction of the track and its supports, the construction of the car and the manner of mounting the same, and also in the construction of the switch and the means of shifting a car from an upper to a lower track, or *vice versâ*. 10 claims.

4407. "Improvements in electric railways." J. B. MCGREW. Dated March 21. 8d. Relates to underground conduit electric railways. 7 claims.

5344. "Improvements in apparatus for measuring the strength and electromotive force of electric currents." H. H. LAKE. (Communicated from abroad by M. M. Garver, of America.) Dated April 8. 8d. Consists in apparatus for measuring the strength and electromotive force of currents of electricity. In accordance with the special construction adopted, the instrument may be arranged either as an ammeter or device for measuring the strength of a current in ampères, or as a voltmeter for measuring the electromotive force of a current in volts. 10 claims.

5782. "An electric lamp for water closets." A. HIORTH. Dated April 16. 6d. The object of this invention is to provide a means for throwing electric light on the seat of water closets by raising the lid, thereby allowing the user to ascertain whether the seat is clean and the closet generally in proper order. 1 claim.

CORRESPONDENCE.

Telegraph Statistics.

The statistical notice in your No. of November 28th, "Use of the Telegraph," is wrong in all figures except in those concerning Great Britain. The correct figures, showing the number of telegrams for every 100 inhabitants (1888) are as follows: Great Britain, 140; France, 80; Germany, 42; Italy, 30; Austria, 22; Hungary, 19; Russia, 9.

The respective figures for 1889, if you care to know, are, according to the reports made by the Telegraph Administrations to the International Telegraph Bureau at Berne are: Great Britain, 163; France, 88; Germany, 45; Italy, 26; Austria, 20; Hungary, 19; Russia, 9. The rhapsodic correspondent of *La Lumière Electrique* must tune down his dithyrambic; he may see from this that his country's civilisation, its industrial progress and intelligence, are just half way to those of Great Britain, and not so very close as he deems fit to infer from incorrect figures.

F. Hennicke,
Leippgerstr, 15, *G.P.O.*

Berlin, W., *December 6th*, 1890.

Count Mattei's Coloured Electricities.

My attention has been called to your notice in the November 21st number of your Journal of my published analysis of Count Mattei's so-called "Electricities." You very properly take exception to the inaccurate statements purporting to show they are not electrical. Permit me to explain. I did not anywhere publish the report. Mistakes have occurred in the publication. The words "electrical" (except when quoted as the name of the preparations) should in every case have been printed "magnetic." The absence of electrical properties was shown by the use of the gold leaf electroscope, and by pith-balls. Unfortunately this was omitted in the report as published.

As an old pupil of the late Prof. Guthrie, whose certificate I gained at the Royal School of Mines, I am not likely to confuse electricity with magnetism, or to be anxious, as your last words suggest, to bolster up anything in the way of quackery.

While pointing out such an inaccuracy of nomenclature, it would have done even greater service to science had you further pointed out the utter absurdity of pretending to thus bottle up either electricity or magnetism in liquids for curative purposes. Your Journal is so widely quoted that an authoritative statement from you would do great good in such a matter.

To the scientific mind it may seem even puerile to attempt to show scientifically that such claims are untrue, but, unhappily, it is necessary to do so for the benefit of the general public. Who else would believe it for want of any attempt at disproof.

Alf. W. Stokes.

[We are very pleased to insert this letter, and we hope that our correspondent's disclaimer will meet with general publicity.—EDS. ELEC. REV.]

Electric Light on Shipboard.

In his interesting letter on the above subject in your last issue, Mr. Rankin Kennedy says:—"The lead-covered wire, without a continuous insulation of vulcanised rubber, is a failure on board ship."

As this statement is not borne out by facts—at all events so far as my own experience is concerned in the lighting of ships of war—it seems to me well that it should be questioned.

The English Admiralty have now for some years employed for a large number of their ships lead-covered cable, with insulation composed of yarn impregnated with bitumen, and as they still continue to specify this combination, it is presumable that they find it to be satisfactory in practice.

Messrs. Sir W. G. Armstrong, Mitchell & Co., of Elswick, have also employed similarly insulated and protected wire and cable throughout a number of war vessels, and I am able to state that with due care in jointing, and in seeing that the cable was both properly handled during the process of fixing, and well made in the first instance, the results have been good.

With insulation of this class it is, of course, highly necessary that the sheathing be made perfectly watertight at all joints; but this is effected by lapping the insulated joint with sheet lead, or covering the joint with a lead sleeve and soldering the whole all round.

Mr. Kennedy's unsatisfactory experience may have been due to this operation having been imperfectly performed, or possibly in the cases on which he bases his opinion the cables may have been injured in erection, or fixed without protection in places where they were liable to violent mechanical wear and tear sufficient to perforate the lead covering. For such localities lead-sheathed cable, however insulated, is obviously unsuitable unless protected with an additional covering of wood or sheet iron.

Provided the joints are made thoroughly watertight, and the lead is maintained intact, the only places where moisture can find its way into the insulation is at the extremities of the wires. There is, however, no great difficulty in properly constructed fittings, suitably placed, in arranging that such ends are kept dry, and where necessary, the wires can be sealed into the fittings, so as to be practically watertight.

On board ship, even more than in the case of land installations, films of condensed moisture are very apt to become deposited on the slate or porcelain bases of switches, cut-outs, &c., and ship engineers are very liable to attribute the resulting defective insulation to bad cables and wires, when these are really in no way to blame.

I have found that in such instances the deficiency of insulation due to this condensed moisture can be removed by electrolysis, it being sufficient to connect one pole of the dynamo to the ship's plating through a safety resistance of one or two lamps, and the other to the lamp circuits, and run the dynamo for a few hours. This has the effect of decomposing the moisture, and the result as regards improved insulation is surprising.

A. A. C. Swinton.

December 8th, 1890.

The Electro-Deposition of Copper.

With reference to your answers to the eight points selected by me, in which your statements with regard to the Elmore process were seriously incorrect, and in which you requested me to point out your mistakes, I would remark:—1. You accept my correction, but ask me for a statement as to the number of tanks and of ampères required for depositing 20 tons per week. Both these points are given in Dr. Hopkinson's report from which you have quoted, and I would be obliged by your inserting it in full. Yet, as the matter still seems to present some difficulty to your mind, I give the simple calculations.

Taking 1·18 grammes as the weight of copper deposited per ampère-hour, then 600 ampères for 150

hours, in 60 tanks, give $1{\cdot}18 \times 600 \times 150 \times 60 = 6{,}372$ kilos., or slightly more than 6 tons.

Four circuits, therefore, of 600 ampères, or 2,400 ampères in all, will give about 24 tons per week. By a similar calculation, we find that four circuits of 500 ampères each will give slightly over 20 tons per week.

With a current density of 16 ampères per square foot of cathode surface, each tank will require about 32 square feet of cathode, equivalent to a tube of about 10 feet long and 1 foot diameter, while the total cathode surface will amount to 7,680 square feet. We have, therefore, instead of 287,620 ampères, and 15,979 square feet of cathode surface, as given by you, somewhat over 2,000 ampères, and slightly less than 8,000 square feet of cathode surface.

2. I accept your disclaimer, but it is impossible to see the object of your calculations, except to support your contention, which is absolutely opposed to the experience of years, viz., "that to deposit 20 tons per week would involve the use of enormous tanks worked under conditions that would be impossible, except by a heavy outlay for tank space."

My 4th, 5th, 7th and 8th points have not been denied by you.

You state, however, that I claim that the Elmore process enables the size of the tanks to be reduced. This was not my statement.

A tank must be large enough to contain the article which is to be made in it, and this depends entirely upon the requirements of the trade.

I will repeat my statement in slightly different words, in order to make it as clear as possible.

Cæteris paribus, the weight of metal which can be deposited in a given time with a given tank plant, varies directly with the current density.

It may be stated with certainty that where coal is cheap, as in England, copper refiners would gladly work with a higher current density than they generally employ, if they could secure a good class of copper.

With regard to the remaining point (6), you endeavour to weaken the importance of the proofs I have brought forward substantiating the other seven points, by referring to them as "side issues."

I am, however, ready to accept your view that the sixth point is the crucial one.

Now, you quoted from M. Fontaine's book the cost of refining in the Norddeutsche Affinerie as £8 per ton, the other two establishments then mentioned working at over £12 per ton. You enquire from the former whether the figure is correct. The answer is just what might be expected.

They state the figure is incorrect.

This strengthens my point.

For as the price for electrically deposited copper in the open market is less than £8 per ton, and it is certain that they are not working at a loss, we may safely assume that it costs them less than £8 per ton.

Why then is Dr. Hopkinson's estimate of £5 per ton so far wrong?

Why, again, should this estimate "be trebled," as contended by you?

It is hardly consistent on your part to suggest now, as you appear to do, that if the price is so low, the Elmore Company will find their profit very small, owing to competition.

You fail, also, to distinguish between the price of the raw material produced in copper refineries, which afterwards has to be worked up into finished articles, and the price of the finished article which is produced by the Elmore method during the process of refining.

In answer to your two queries (*a*) and (*b*) on this point I would reply:—

(*a*) Copper articles produced by the Elmore process *can* compete most advantageously with copper otherwise prepared, and this in the case of articles for which there is a large demand, and in which the superiority of the article produced at once secures a market.

This point may be determined at once by comparing the market prices for articles such as are particularly adapted for production by the Elmore process with even the exaggerated cost assumed by you.

(*b*) The economies of the Elmore process *are* such as to enable the company to sell a superior article at current prices and leave a substantial profit.

W. Stepney Rawson.

December 9th, 1890.

P.S.—Referring, separately, to the letter of Mr. Desmond G. FitzGerald, I have only to say that as regards the work done in the tanks themselves it is immaterial whether they are in series or parallel; but for practical work there is an enormous difference.

The "parallel system" teems with practical difficulties, and I do not think it need be seriously discussed.

As I am not responsible in any way for the article in the New York *Electrical Engineer*, with which, I beg to inform you, I had nothing to do, I will not trouble to follow the several arguments by which Mr. FitzGerald endeavours to justify the employment of a parallel system of electro-depositing. I would simply ask him to be so good as to let your readers know where dynamos can be obtained which will, with a reasonable efficiency, give an output of, say, 100 H.P., with a terminal E.M.F. of 1 volt?

His letter points to the existence of such a machine, although a calculation of its internal resistance appears to place it in the same category as "the bath." Yet as the feasibility of a parallel system depends upon its existence, he, perhaps, can give us the necessary information. It would appear from Mr. FitzGerald's letter that he is responsible for the calculations in the original article, the errors of which I have pointed out, for he says (no doubt inadvertently), "only an outsider would suppose for a moment that *our* data in relation to a single tank were intended to imply, in case of extended operations, the construction of an enormous reservoir."

[In the above communication, Mr. Stepney Rawson's familiar 8 points again make their appearance. The letter reached us too late to comment upon it at any length, but it confirms the impression we expressed that the "absurdity" which was so very apparent in Mr. Rawson's previous letters, recoils on Mr. Rawson himself. Our correspondent says we have not "denied" some of his points, as he previously said we had not "answered" some others. They were all dealt with by us, and we see no reason whatever to add to what we have already said about them. On the new points raised in the letter, Mr. Rawson takes for granted that a price which is incorrect is incorrect in the direction he wants it to be. We are not satisfied that the reasons he gives settle the question. Many other points assume the success of the Elmore process, which is, of course, all very well for Mr. Rawson, but may be held under reserve by others. We may say, with all respect, that, in reply to our crucial questions, we expected something more than an italicised "can" and "are." There is a P.S. which shows Mr. Rawson to have been a diligent reader of Mr. FitzGerald's letter. We will leave Mr. FitzGerald to reply to the questions asked him, and for our part we ask Mr. Rawson to kindly refer again to Mr. FitzGerald's letter, where he will see the plural number is largely used throughout, as it almost invariably is in scientific articles or papers dealing with data actual or suppositious. Mr. Rawson must try again. He should not seize upon such slender data to father upon an individual an article for which the Editors of the ELECTRICAL REVIEW are alone responsible.—EDS. ELEC. REV.].

Reviews.

I will only so far break through the rules of journalistic etiquette as to say that your recent critique on my "Practical Electrical Notes," second edition, is somewhat severe.

But you make a direct misstatement when you say that the machines are undescribed. *Vide* page 164 *et seq.*

Now, as such a statement is likely to do my book real harm, and as it is quite incorrect, I trust you will do me the justice of inserting a correction in your next issue.

W. Perren Maycock.

[Our reviewer admits that there are descriptions, of the trade circular description, but they are not full enough to be of much value.—EDS. ELEC. REV.]

Improvements in Telephone Exchange Switchboards.

The articles in your impressions of October 24th and 31st on the above subject are, without question, of considerable interest to all persons connected with telephonic enterprise in this country, and perhaps in a greater degree to those who are in charge of foreign systems, and have not opportunities of making themselves personally acquainted with the various developments and improvements which are from time to time being made.

After carefully reading the two articles in question, it seems that something more may with advantage be said on the subject of switchboards for small exchanges. Without doubt, both the double and single cord systems have individual points which are valuable, and which cannot easily be obtained by combination, and it therefore becomes a question as to which system gives the greatest efficiency.

When comparing the two systems, it may, in the first place, be said that it is objectionable to have in a telephone circuit more contact points than are absolutely necessary. Therefore, in principle, the single cord system is preferable, and it remains to be seen whether this advantage can be retained in practice satisfactorily. I do not hesitate to say that it can, and that other advantages can also be obtained.

The points to be aimed at are :—

1. A celerity in operation and general efficiency.

2. Simplicity in the arrangement of the circuits, and freedom from more circuit breaks than are necessary.

With regard to these points—

1. (*a*) Mr. Kingsbury claims that the number of movements in effecting a connection and disconnection of two wires is the same on both boards. On the single cord board the three first movements given by Mr. Kingsbury are in reality of much less value than is attributed to them. They certainly are not equal to more than 1½ movements, as the plug used is the same in each movement, and any one who has been accustomed to operate both boards will find this to be so. Therefore, I make the operating of the single-cord board equal to, say, 5½ movements, and the double cord board to 7 movements. Mr. Kingsbury asserts that the double cord movements are done more quickly. I do not see what reason he can give, and in practice it is not the case. On single cord boards of the latest design only four movements are required, if an automatic ringing machine is employed, and five if the ringing has to be done by hand. Therefore, as far as celerity is concerned, the single cord system has the advantage.

(*b*) The single cord system has been in use for some years, and, when properly fitted, has, as far as I am aware, had no objection of importance brought against its efficiency.

2. As to simplicity of circuits, &c.—When two lines are connected on the single cord board there is only one point of contact, *i.e.*, that between the called plug and the calling jack. On the double cord board there are four, *i.e.*, two plug and spring jack contacts, and two contacts in the key which is inserted into each pair of cords to enable the operator to speak and ring. Every practical telephone man will agree that nothing gives more trouble than key contacts, and this is why they have been entirely done away with on the single cord boards.

It is evident that keys might have been fitted on the latter, and that if this had been done the movements required to effect a connection and disconnection would have been reduced to four as compared with seven on the double cord board.

Mr. Kingsbury refers to the size of the single cord board described in your article of October 24th, and I agree with him that it might be reduced, and this can be done without in any way causing the difficulty in the plugs as he suggests. This is not an important point, however, as it is not usual to place two one hundred line boards side by side. From some cause or other it is usually found advisable to put in a new board when the exchange outgrows the capacity of the existing one. The boards are made for 30, 50, 100, and 150 lines in the style shown in the diagram of October 24th. The canopy pattern board is used for larger sizes. The "cross connections" are therefore never necessary. Mr. Kingsbury points out that the double cord board which he advocates as being the best is only 23 inches wide, and is for 100 subscribers. "Thus 500 subscribers would occupy a space of less than 10 feet." I need only say that it would be quite impossible to work 500 subscribers in a space of 10 feet. In the majority of exchanges two operators are required for 100 to 130 subscribers, and seven to ten operators cannot work with a sitting space of 16 inches in the one case and 10 inches in the other.

I think it has been shown that there is a saving in operators' work on the single cord system, and that other advantages, such as absence of keys and their accompanying faults are obtained.

H. F. Jackson.

December 3rd, 1890.

Since writing the above letter I have seen the further correspondence in your issue of December 5th. Mr. Kingsbury writes at great length in explanation of his previous letter, but without, it seems to me, entering on any new ground with the exception of the question of accessibility. All the working parts of a single cord board can readily be reached from the back, whereas the operators must be interfered with if any fault occurs in the key-board of the double cord system.

H. F. Jackson.

December 8th, 1890.

Seeing by Electricity.

With reference to your note *re* "Seeing by Electricity," *Phainein* means to show. Granted; but we want to express not showing, but seeing by electricity. The positiveness of the assertion—"*telope*," is certainly not right, as "*ope*" represents nothing connected with the subject—appears crushing; but its author seems unaware that *ops* means the eye, and that "OP" is the root from which comes the words most commonly used in the Greek language with regard to sight, to wit, *omma*, the eye; *opsis*, sight; the fut. aor. pass. and pft. mid. of *horao*; and it would not be surprising if the words connected with *skopos*, which we get in telescope, and mean, generally, reflection based upon sight, were all derived from the same root. *Telephane* is a sweet-sounding word, but it does not quite fulfil the required conditions. Why did so severe a maker of words write *optikos* nom. masc. sing., and then *phanerous* acc. masc. pl.? *Teleopt* would not do, as by itself it might easily be supposed to mean—roasted from a distance.

A. C.

Incandescent Lamp Breakages.

Would you kindly inform me if any explanation can be offered as to the reason why fully 80 per cent. of breakages in lamp filaments occur from $\frac{3}{16}$th to $\frac{1}{4}$th above the spot where the end of the filament is cemented to the platinum.

The lamps to which I refer are Edison-Swan 55 v. 8 C.P., and are Brush capped. They are used for ship-lighting. Is it possible that vibration may be a prime factor as to the cause.

Hoping you will pardon my troubling you.

Walter Poyton,
Electrician R.M.S., "Oroya."

December 7th, 1890.